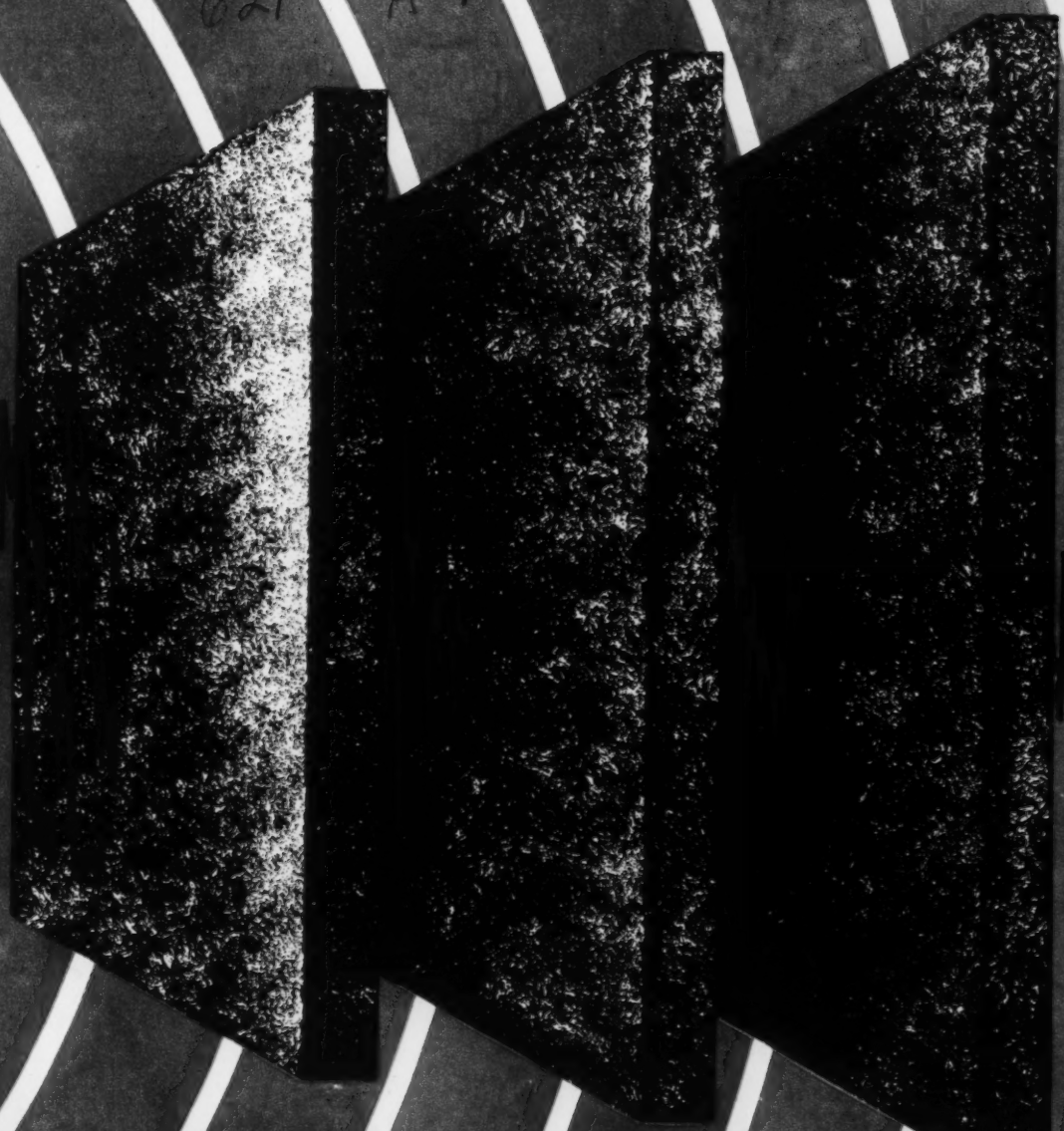
621
A-1

JULY 26, 1956
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Noise Control

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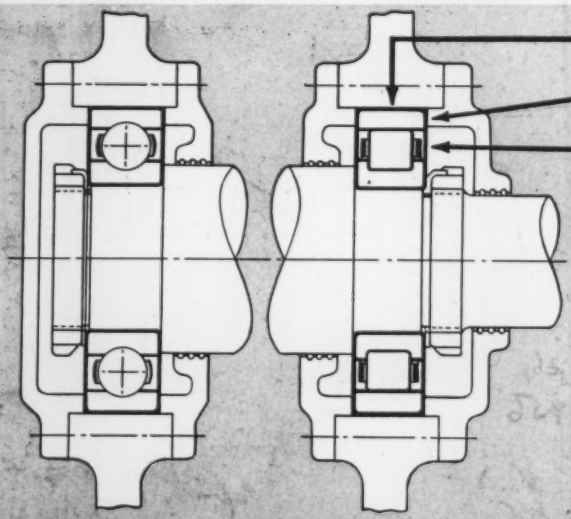
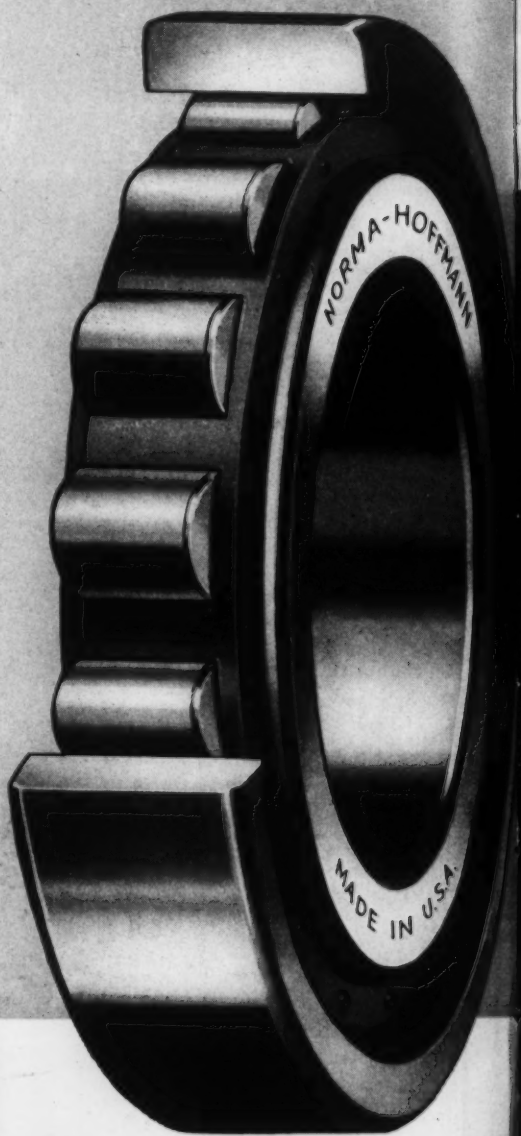
For Shaft Expansion *and/or* Heavy Radial Loa

use NORMA-HOFFMANN

Precision Cylindrical Roller Bearings


Outer Ring Mounted With Tight Fit In Housing
Outer Ring Rigidly Clamped Endwise (No Looseness or Slippage In Housing)
Rollers Move Endwise As Shaft Expands

Typical Mounting Using Clamped Ball Bearing At Lightly Loaded End Of Shaft And Clamped Roller Bearing At Heavily Loaded End



CHECK THESE ROLLER BEARING ADVANTAGES:

1. No Looseness Required Between Outer Ring and Housing — As With Self-Contained Bearings.
2. No Possibility of Endwise Cramping of Bearings — A Frequent Cause of Heating and Early Failure.
3. Extra Quiet and Trouble Free Operation — Due to Elimination of Looseness.
4. Extra Heavy Radial Load Capacity Plus Resistance to Shock and Vibration.
5. Precision Limits Used Throughout Permit Extra High Speed Operation.
6. Interchangeable With Standard Single Row Metric Ball Bearings.
7. Available Also in An Extra Light Series Where Overall Weight Is Important.

Norma-Hoffmann Engineers, specialists in bearing design and application, will help you with your problems. Ask for their services.

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ITEM

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FOUNDED 1911

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New Ross controls
...give operator time out!
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Now . . . take the sequencing of pneumatic valves out of the operator's hands. Pre-set patterns of operation are carried out by the machine itself. With these new Ross valves, your cylinders can be sequenced by position or time. A complete range of control valves is available.

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Ross OPERATING VALVE COMPANY

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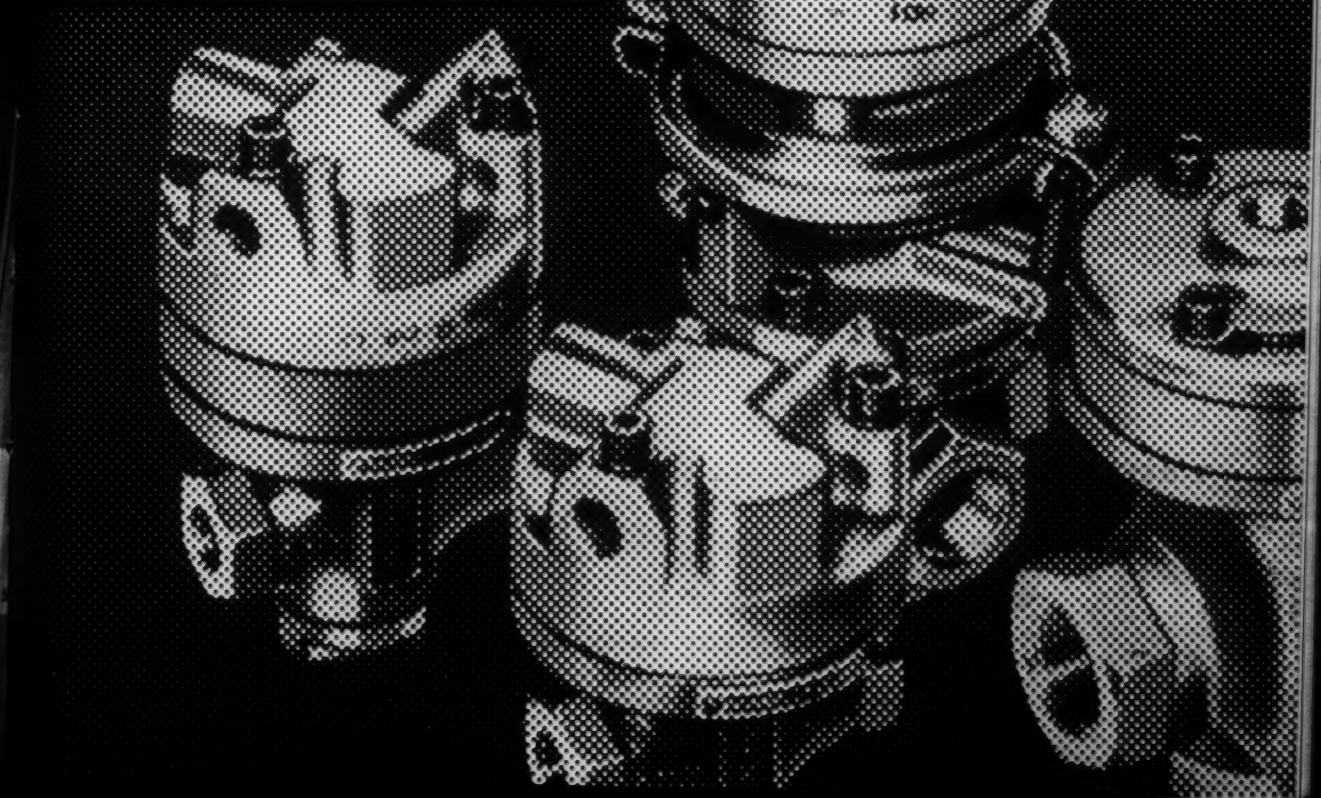
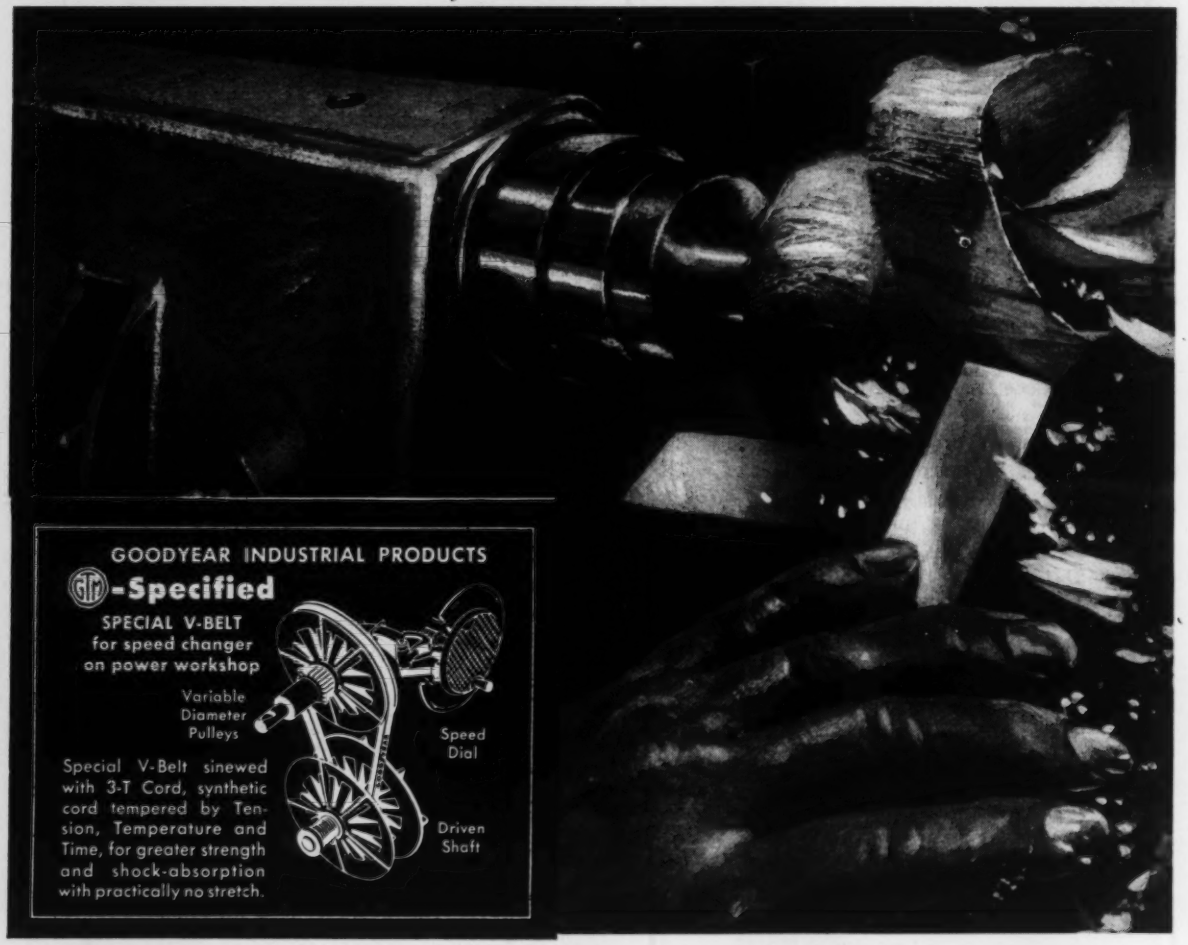
—ITEM 504—





Secret of a New Twist in Power Workshops

A LEADING manufacturer of home workshop power tools wanted to make speed changing in an all-new model easy and convenient. Dialing the operation on a speed-dial was the answer. A simple twist of the dial and the operator could have the right speed. The various speeds could be obtained by changing the distance between halves of split pulleys. This would vary the diameter of the pulleys and the resultant r.p.m. But how to get a belt that could withstand the constant changing in diameter and not stretch was the problem.

The G.T.M. – Goodyear Technical Man – was called on for help. He worked with the problem for a year during the planning and developing stages, finally delivered a special, precision-built V-Belt – sinewed with Triple-Tempered (3-T) Cord. This super belt not only outperformed competitive belts by withstanding *four times as many stalls* at 2500 r.p.m., but also ran much quieter and smoother – completely solving the problem.

How can the G.T.M. help solve your V-Belt problem? You can consult him through your Goodyear Distributor or Goodyear, Industrial Products Division, Akron 16, Ohio.

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

V-BELTS with TRIPLE-TEMPERED (3-T) CORD by

GOODYEAR

THE GREATEST NAME IN RUBBER

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

July 26, 1956
Volume 28—No. 15

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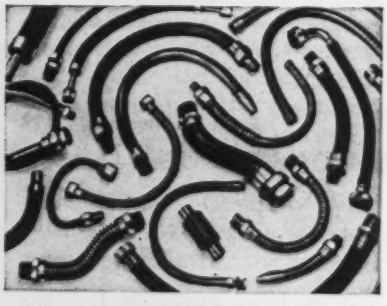
American Vibration Eliminator absorbs vibration in piping leading from refrigeration compressor . . . stills noise, ends piping failures.

Standard line of flexible metal connectors simplifies isolation of vibration in rigid piping



Typical American flexible assemblies available to convey both liquids and solids, absorb vibration, compensate for contraction and expansion in rigid piping; connect moving parts, misaligned ports; and to protect delicate tubing, wiring.

UNCONTROLLED vibration in pipelines often results in objectionable noise, cracked piping, high maintenance costs, and expensive shutdowns.

American engineers have designed a number of flexible metal hoses, connectors and conduits that are widely used by design engineers and others to solve this problem.

American Vibration Eliminators (illustrated here)—short sections of seamless flexible bronze (98¾% copper, 1¼% tin) tubing used to minimize noise and vibration in rigid piping of air conditioning, refrigeration and other installations may be adapted to your product or problem.

Flexpipe* standard flexible connectors—seamless, tin bronze tubing, corrugated for flexibility, with tin bronze wire braid covering—used in wet heat systems by contractors, and in other installations to convey air, gas, oil, steam or water, dampen noise in piping, take care of expansion and contraction, simplify installations.

Sealtite* flexible, liquid-tight conduit—tough polyvinyl chloride jacket extruded over flexible metal core—protects wiring outdoors and in . . . in wet or corrosive spots. Highly flexible: takes up movement, absorbs vibration, easily installed.

Whatever your piping problem, there is a standard American flexible metal assembly right for the job, or American engineers will design one to your specifications at no extra cost. For more information, write for Catalog CC-400. The American Brass Company, American Metal Hose Division, Waterbury 20, Conn.

*Trade Mark 56176

WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL HOSE AND TUBING

an **ANACONDA**® product

Engineering News Roundup

Magnets in Varied Shapes Made from New Powder

Compound, Molded or Cast, Stays Magnetized

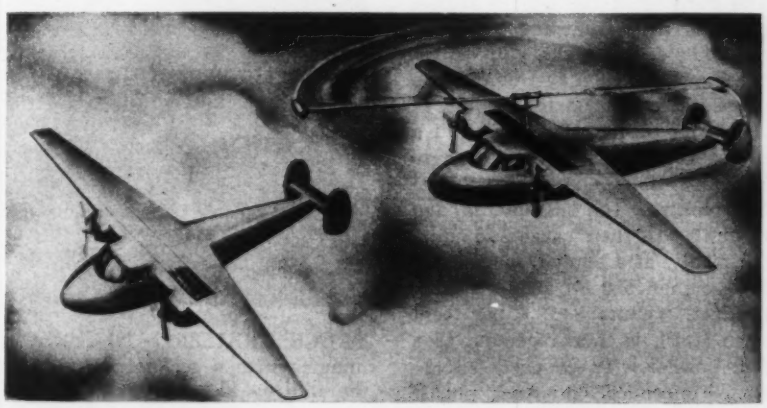
PITTSBURGH, PA.—A recent product of research at Westinghouse Electric Corp. is high-purity manganese-bismuth in powdered form. The powder can be molded and cast into varied forms of permanent magnets which demonstrate unusual ability to retain their magnetism. Announcement of the new material was made by Dr. Clarence Zener, acting director of Westinghouse research laboratories.

Dr. Zener said that the magnetic properties of manganese-bismuth have been predicted for years but that, until now, the alloy could not be made pure enough to realize its potential abilities.

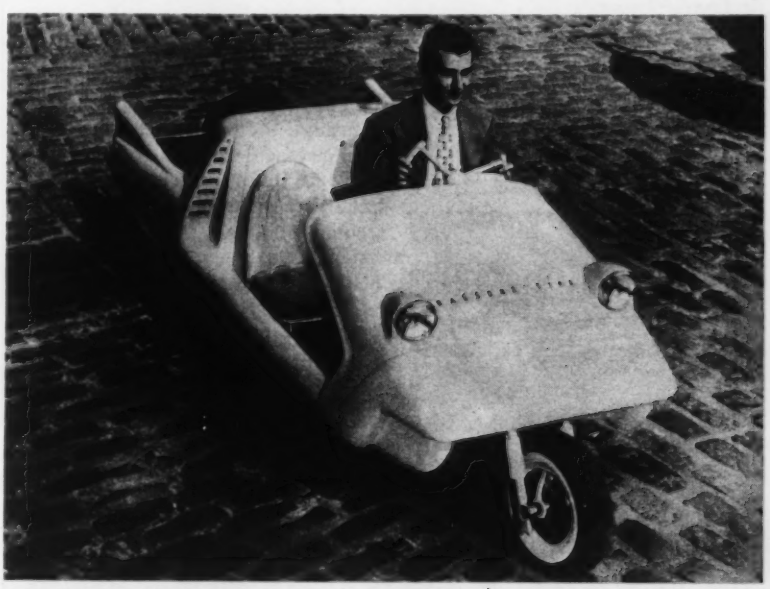
Dr. Zener said further that magnets of manganese-bismuth derive many of their unusual properties from being powder-type magnets. Each manganese-bismuth particle, about 40 millionths of an inch in diameter, is itself a tiny magnet. The particles are "insulated" from one another by imbedding them in a plastic binder, or matrix, which forms the body of the magnet and keeps the particles separated.

"Manganese - b i s m u t h magnets . . . can be easily drilled, tapped, and cut—even with a penknife if a suitable plastic binder is selected. . . . Magnets can be cast or molded, possibly even extruded, into any shape desired." Dr. Zener also pointed out that because the plastic binder is an electrical insulator, manganese-bismuth magnets are nonconductors of electricity.

A program of further development is now in progress under the



RETRACTABLE ROTOR is the feature of this otherwise conventional plane under development by Hiller Helicopters for the Air Force. The tip-powered, two-bladed rotor would be used for vertical take-off and landing, then folded and retracted into the fixed wing. Actual testing of a 25-ft rotor system will be undertaken soon at Wright Air Development Center.



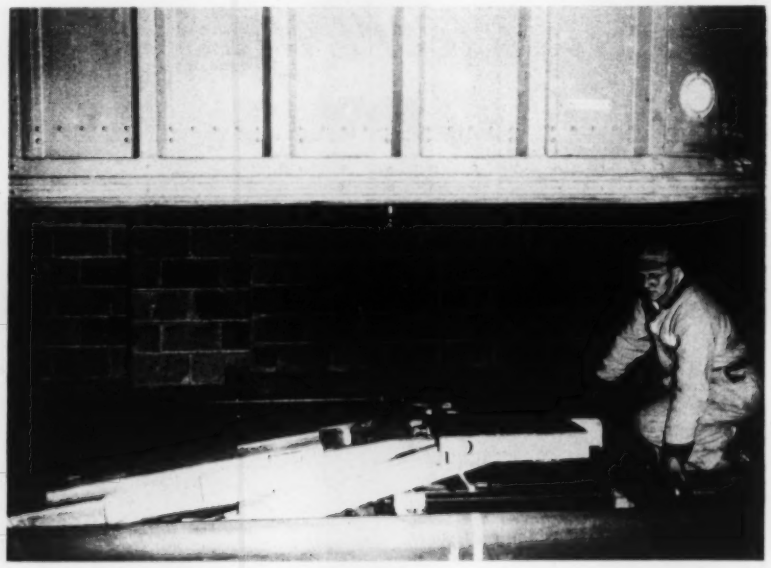
THREE-WHEELED CAR, called "Star," is this new sports and utility vehicle recently introduced by Bassons Industries Corp. Glass fiber body is mounted on welded tubular steel frame. Power plant is German-made J.L.O. engine, 1 cylinder, 2 cycle, rated 10 hp. The 12 v electrical system includes a 45-w generator. Wheels use 4 by 8-in. tires, have rear tread of 40 in. and wheelbase of 86 in. Overall length is 125 in., width 49 in., and height 33 in. The "Star" weighs 400 lb. Estimated top speed is 70 mph, and cruising speed is 40 mph. Gas tank holds 3 gallons and gas economy is 80 miles per gallon.

←Facing Page—ITEM 506

supervision of J. A. Osborn, manager of magnetic materials development.

Mr. Osborn disclosed that the super-pure manganese-bismuth is prepared in this way: Manganese and bismuth are ground together to extremely small size under an inert atmosphere of helium gas. The purpose of the helium atmosphere is to prevent the powdered materials from catching fire spontaneously, which they would do on exposure to oxygen in the air.

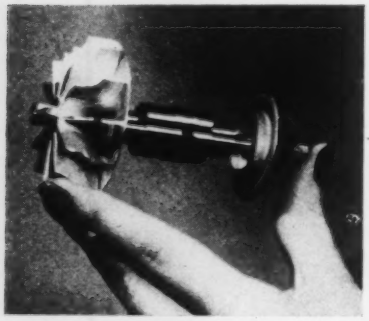
The mixture is then sealed in a glass vessel under low-pressure helium. Using precise temperature control, the manganese and bismuth are then caused to unite chemically at a temperature slightly less than 520 F. The resulting product, virtually 100 per cent pure MnBi, is then reground to a fine powder. These particles are then imbedded in the plastic matrix, oriented in a powerful magnetic field and molded to shape.



TRUCK TRAILER IS SECURED TO A FLATCAR by one man in 2½ minutes with a semi-automatic, folding mast that is power-raised to lock the trailer's kingpin. The trailer's front end is supported independently of its landing gear. A cushioning device in the mast controls longitudinal movement of the trailer. When not in use, the mast folds down to a height of 8 in. above the floor of the flatcar so that tractors and trailers can pass over it easily for loading and unloading. The mast was developed by American Car and Foundry Div. of ACF Industries Inc. and Rail-Trailer Co.

Small Pump Works Hard To Cool Planes

SANTA MONICA, CALIF.—A turbine powered, small-size refrigeration unit has been developed by Carrier Corp. for new Douglas DC-8 airliners. By extensive use of aluminum, the weight of the entire system has been held to 150 lb.



The miniature compressor in the system is driven by a jet of air bled from the plane's engines. At one end of the compressor shaft, turbine blades which receive the jet blast are not much larger than a jar lid. At the other end of the shaft is a compressor wheel slightly larger than a silver dollar.

Tip speed of rotor blades is higher than the speed of sound through the refrigerant. The entire compressor weighs only 8 lb and is 100 times more powerful than the corresponding unit in a household refrigerator.

Fighter-Tanker Contacts Made with Radar Beacon

WASHINGTON, D. C.—Certain operating squadrons of the U. S. Air Force now use a radar beacon, made by the Sperry Gyroscope Co., to facilitate accurate aerial rendezvous. The new device enables long range aircraft of the Strategic Air Command to locate each other and pinpoint the exact positions of tanker planes, regardless of darkness or weather. Signals can be triggered automatically by the interrogating radar in planes hunting the tanker aircraft.

Designated APN-69, the new radar equipment was developed jointly by Sperry and the Wright Air Development Center. Although compact and small in size, it produces a high-power coded signal with reliability that has been successfully tested by the Air Force during the last two years. Operational suitability tests of similar equipment included precision contacts during a nonstop flight of B-47's to Tokyo and return in 1954. Refueling planes had been strung out near Pacific bases.

In air-to-air operations, the beacon is installed in designated rendezvous aircraft. Other aircraft wishing to "home" on the

Front Cover

Does noise look as unpleasant as it sounds? Through the magic of George Farnsworth's brush, on the front cover we are enabled to see just what happens to a whopping big noise when it hits a trio of acoustic barriers. How to cut noise down to size is told in the article, "How to Use Acoustical Materials," by Richard N. Hamme, beginning on Page 68.

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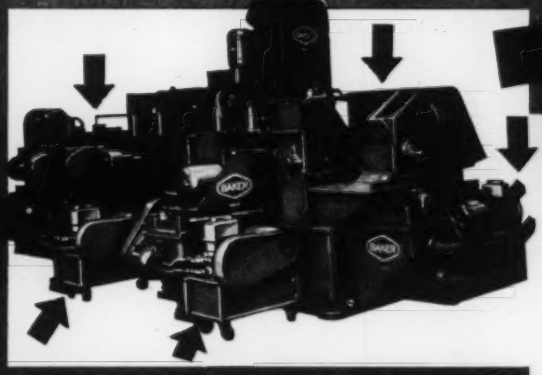
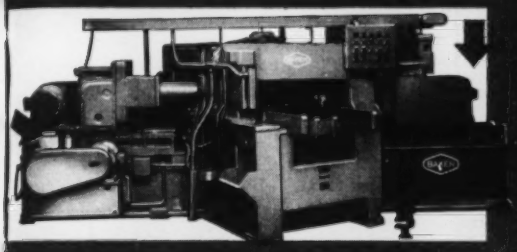
OILGEAR "JK" FLUID POWER FEED PUMPS



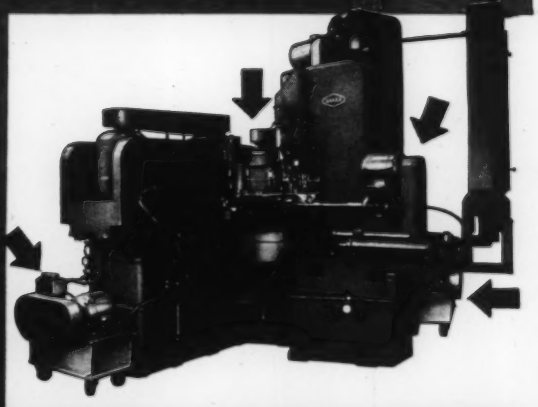
AS APPLIED TO BAKER BROTHERS MACHINES

HOW CAN YOU USE THESE SIMPLE, VERSATILE, EASILY APPLIED, PROFITABLE UNITS?

Baker Brothers, Inc., pioneers in machine building, users of Oilgear Feed Pumps since 1925, employ Oilgear "JK" Fluid Power Variable Delivery Feed Pumps on a host of machines including the headline-making 100-foot-long transfer machine and their own commercially available portable hydraulic power unit which you can see in photos Nos. 1 and 3 on this page.

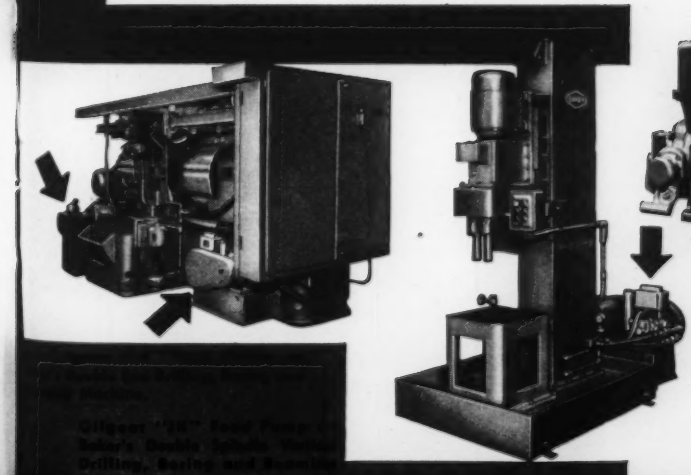


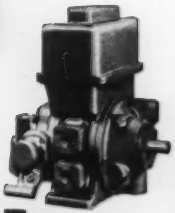
The Oilgear "JK" Feed Pump offers many advantages, not the least of which are easy applicability and accessibility. There's no need in many cases for machine redesign and engineering. And this unit does so much to speed cycle time—traverse speed for example can be 265 times feed rate—that production rises dramatically and costs subside. Both coarse and fine feed rates can be varied infinitely so you at once discover the best rates for your work—and the automatic built-in compensator holds the selected fine feed *unvaryingly*. All functions are controlled automatically, semi-automatically or manually.



Evidence of Oilgear "JK" dependability is growing. In one large automotive plant, now 75% changed over to Oilgear, hydraulic maintenance staff was cut from 6 men to one man per shift. In another great automotive plant, the records show Oilgear is found to give the finest service of all.

There's much more to tell especially about two new units added to the "JK" line. Why don't you send for free literature that gives all the facts and figures. So you won't forget, send for it now.





Type "JK" Pump Built in four sizes.

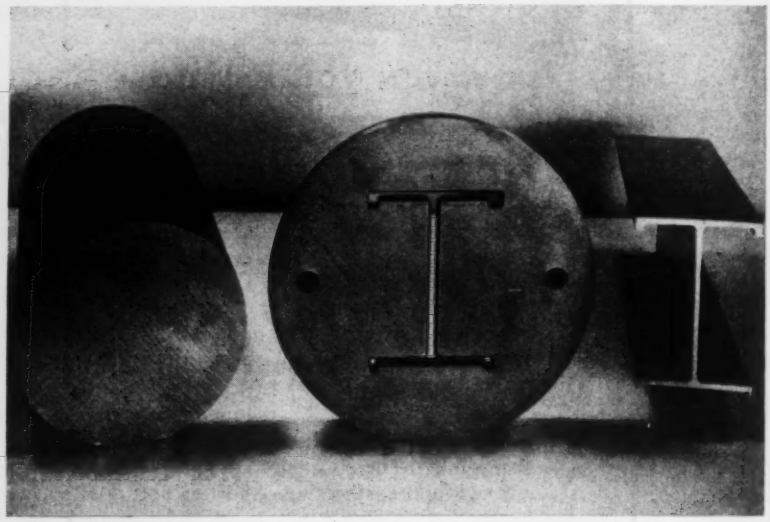
THE OILGEAR COMPANY
1568 W. PIERCE STREET
MILWAUKEE 4, WIS.

OILGEAR
Fluid Power

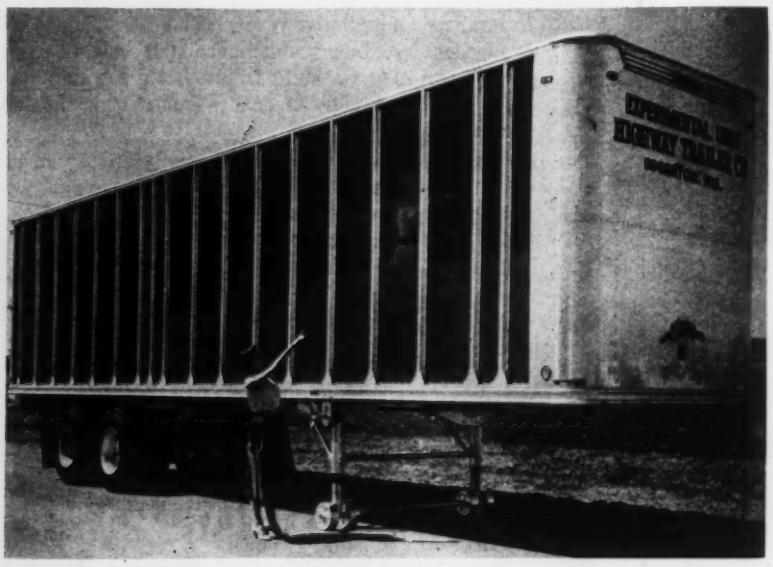
PIONEERS . . . NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES

beacon dispatch interrogating radar pulses to trigger the beacon. In response to the proper interrogation signal, the beacon in the rendezvous aircraft transmits a coded reply. The operator of the interrogating radar is thereby able to identify the beacon-equipped aicraft and determine its exact range and bearing.



BIG BRONZE BEAMS, the largest bronze extrusions made to date, have been produced as structural and facing components of the new Seagram Building, New York. Previously, sections of the largest extrusion fit within a 6-in. circle. The I-section above measures 6 by 4½ in. and is extruded in straight lengths up to 26 ft.



TRANSLUCENT PLASTIC PANELS enclose the sides of this new trailer introduced recently by Highway Trailer Co. The builder's "stress panel construction" makes each side wall a load-bearing unit. Plastic sheets are riveted to vertical aluminum exterior posts and to lower and upper longitudinal members. Translucent plastic for side walls and roof reduce total weight of trailer and improve interior lighting for more efficient cargo handling.

Topics

Gas turbines are for the birds —the whirlybirds, that is. Within ten years, the majority of helicopters produced in the United States will be powered by gas turbine engines, according to a prediction by General Electric.

• • •

The problem of heat on the surface of high-speed aircraft is being attacked with fibrous glass. Experiments are being conducted with a porous-skinned fibrous glass fighter plane, which permits air-cooling of the plane's skin at very high temperatures.

• • •

Radioactive boxcars, now past the preliminary design stage, are seen possible within two years. The railroad cars would house equipment for preserving food by irradiation and could be moved about the country for use where the food is.

• • •

Construction of an atomic-powered merchant ship has been approved by the Senate. Reactor for the $37 million ship would be built by the AEC and the rest of the ship, by the Maritime Administration.

• • •

Light conversation — talking over a beam of light instead of a radio beam—is being developed by two Massachusetts scientists. Based on Alexander Graham Bell's photophone, which was never perfected, the present device can carry a voice about 10 mi. Theoretically, the range of communication should be that distance at which the light can be seen.

• • •

Ain't no squares among the folks who have Chrysler cars equipped with record players. Sales of extra records for the Highway Hi-Fi sets show motorists' preference for popular music and ballads.

• • •

Instant rubber is produced by means of atomic "bullets." A process developed by Westinghouse consists of directing beams of 2 million-volt electrons at silicone gum to convert it to silicone rubber. It is claimed that better rubber is produced by this method in two seconds than by conventional vulcanizing in several hours.

Facing Page—ITEM 508→

SIDELINES

are essential to

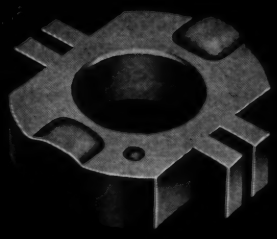
Football

Baseball

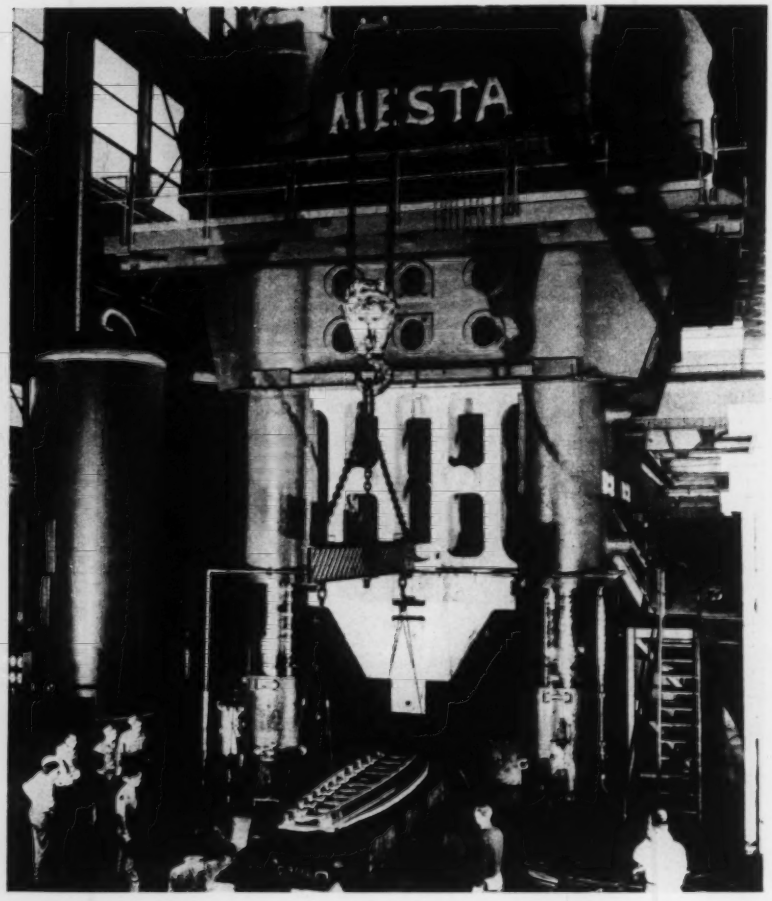
Tennis

but not to manufacturing.

Bound Brook produces no "sideline" products-only the world's finest Powder Metallurgy Bearings and Parts.....



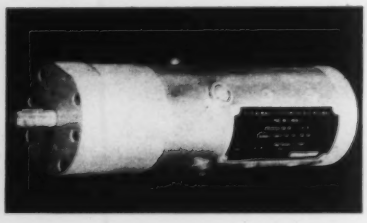
BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J. EST. 1883



LARGEST CLOSED-DIE FORGING is removed from the 50,000-ton Air Force press at the ALCOA works, Cleveland. The record-size forging of aluminum is 13 ft long, 3 ft wide, one ft thick, and weighs 3000 lb. The forging will be used in the Martin XP6M SeaMaster seaplane. The part required 60-ton finishing dies, also the world's largest.

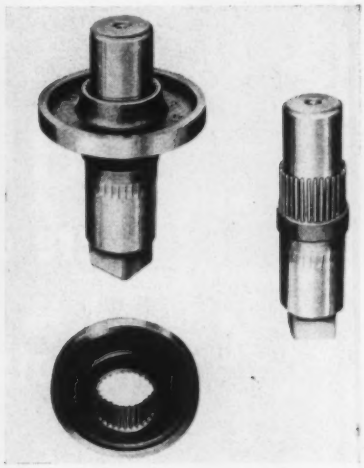
Midget Motor Moves Missile Controls

CONCORD, CALIF.—A new small-size motor developed by Motronics Corp. delivers high power in



limited space to actuate brake-flaps in missiles. The motor delivers 0.208 hp at 28 v dc and draws 28 amp at full load. It will operate from −65 F to 450 F and can be built to handle peak loads of 0.4 hp. Armature speed of 15,000 rpm is reduced by two-stage planetary gearing to shaft output speed of 250 rpm. The four-pole series-wound type motor is 2.1 in. in diam by 6.6 in. long.

Precrash behavior of an airplane is recorded on a new instrument made by Gateway Mfg. & Development Co. The small instrument continuously records and erases data on acceleration, air speed, altitude, fire locations and structural failures. Should a crash occur, a record made during the minutes preceding it is preserved on a sturdy metal plate.



PIN-TYPE ARBOR has been introduced by Scully-Jones & Co. to speed up gear-cutting operations. Gears with involute splined bores fit onto pins around an arbor. The arrangement eliminates use of an arbor press and is claimed to prevent pitch-line runout in gear cutting.

Thermometer, Tractor and Auto Judged Year's Best Designs

CHICAGO, ILL.—Designers in three contrasting fields of manufacturing have received the 1956 awards of the Industrial Designers Institute. Honored for their "noteworthy and fresh approach to the design of mass-produced and nationally-distributed product" were:

William E. Clements, designer of the "Therma Meter," a new type electric thermometer for the nursing and medical professions, produced by Medical Research Institute, Inc.

Jon W. Hauser, American Society of Industrial Designers, for his design of the Model HH Payloader, a pneumatic-tired, four-wheel-drive, self-propelled tractor-shovel, manufactured by the Frank G. Hough Co.

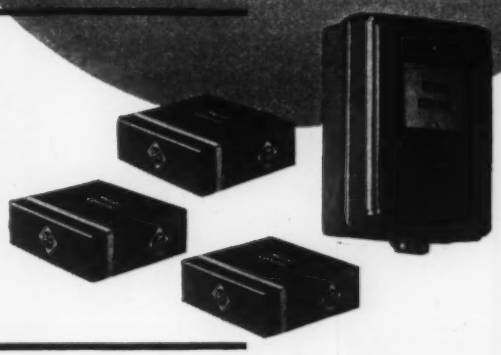
A seven-man design team of the Styling Office, Ford Motor Co., for their design of the 1956 Lincoln Premiere Series two-door hardtop, produced by Ford's Lincoln Div. George W. Walker, vice-president and director of styling for Ford, received the award for the group.

Annual awards of the Institute

ALLIS-CHALMERS

MOTOR CONTROL

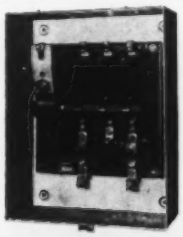
a Complete Line

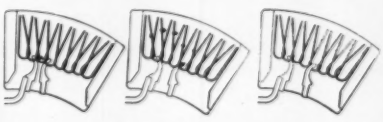


SIZE 0-3 STARTERS

Converta-Kits Permit Easy Modification of Basic Starter

You get MORE . . . more flexibility with Allis-Chalmers control. A screwdriver and the proper *Converta-Kit* are all you need to change a basic Allis-Chalmers size 0-3 starter into the exact unit demanded by your production. *Converta-Kits* are available for push-button, selector switch and electrical interlock modifications. Starter replacement parts—contacts, magnetic coils and overload relays —are also available in packaged kits.





1. Arc across contacts as they start to open.
2. Strong blowout action forces arc to center.
3. Contacts fully open — arc extinguished.

NEW LINE OF SIZE 4-5-6 STARTERS

Quick Quenching Extends Contact and Chute Life

Heart of these starters is a new contactor which uses a revolutionary principle of arc interruption. In centering the arc, increased blowout action and fast quenching result from a combination of thermal convection and magnetic action. Since the arcing time is sharply curtailed, contact and chute life are greatly extended.

A-4988

HIGH VOLTAGE STARTERS

Complete "Line-to-Load" Control and Protection

Allis-Chalmers Type H starters are built in a wide range of ratings for squirrel-cage, wound-rotor and synchronous motors . . . for full or reduced voltage — reversing or non-reversing — with plugging, dynamic braking and multi-speed features. Built into the starter is the type and degree of protection dictated by the application.

What is your control problem?

As manufacturers of a diversified line of industrial equipment, Allis-Chalmers has solved thousands of control application problems. This specialized experience is yours when you specify Allis-Chalmers control. See your Allis-Chalmers representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

Converta-Kit is an Allis-Chalmers trademark.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

—ITEM 509—

For More Information Circle Item Number on Yellow Card—page 19

are based on the professional evaluation of the designers' contributions to the field of industrial design, to the manufacturer, and to the ultimate consumer. All industrial designers—individuals or teams, and regardless of affiliation—were eligible to submit entries.

Guest speaker at the awards presentation was Emanuel M. Benson, dean of the Philadelphia Museum's School of Art. "A fabric, a plate, or a tool," he said, "can be as evocative of a civilization as a poem, a building, or a painting. And the fact that these objects may have been produced in the thousands or millions does not make them less precious. The snob appeal of scarcity only increases the price of an object, not its real worth."

Large Grass-Fiber Shapes Are Mass-Produced

TOLEDO, O.—A new type of press and mold for forming quantities of large plastic shapes from reinforced glass fiber is announced by Sterling Precision Corp. Advantages claimed for the new equipment and technique are economy and ability to form uniform, void-free structures of almost any size and depth. Close dimensional tolerances can be maintained.

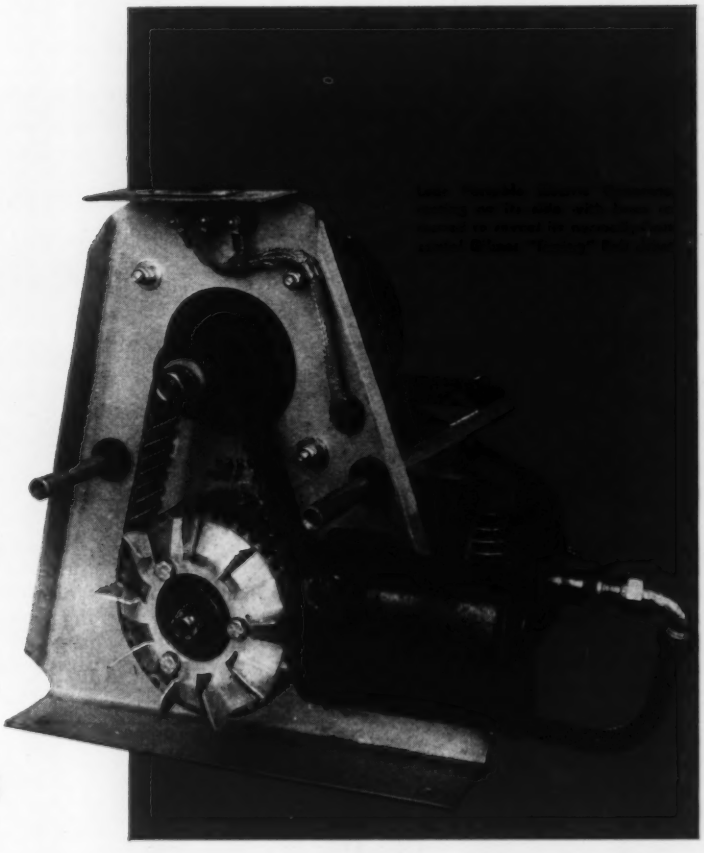
A battery of the new presses is currently producing automobile tops and bathtubs. These presses are fully automatic and produce 120 tons of pressure in a 1-in. power stroke.

Louis D. Martin has announced the opening of his gear consulting business, to be located at 303 Granite Bldg., Rochester 4, N. Y. Mr. Martin was gear engineer for the Eastman Kodak Co. for 30 years. He has been active in the field of instrument gearing and has written a number of articles on the subject, including "Designing Instrument Gearing," MACHINE DESIGN, April, 1948, and "Gear Blanks," MACHINE DESIGN, October, 1952.

AMBIDEXTROUS IRON MAN is this new Series G Printer and Punch developed by Burroughs Corp. Intended for accounting and documentation operations primarily, the machine can process two separate card files simultaneously and automatically select desired data from either or both to produce two related documents of different format. At the same time, and at no loss of speed, new tabulating cards can be punched and printed as new source documents. The equipment processes 120 punched cards per minute, prints 900 lines or 1200 characters per minute.

ONE LONG BORE is accomplished at each stroke on this machine built by Moline Tool Co. for ALCO Products Inc. The machine cuts camshaft and main crankshaft bores in the blocks of 12- and 16-cylinder diesel engines. The boring operation has two phases: first, rough cutting is performed by 3-in. and 7-in. boring bars; then 4-in. and 7-in. bars finish the job.

Required: 12,000 rpm... and only a Gilmer "Timing" Belt drive met the need... with lightness and compactness



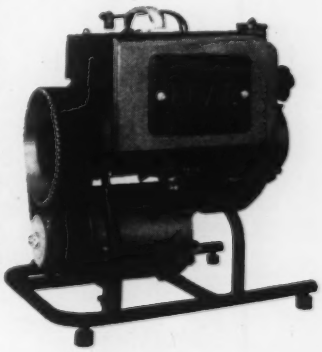
BUILT TO serve as a lightweight, foolproof source of emergency or auxiliary electric power, this new Lear Portable Electric Generator is a miracle of efficiency. Helping to make that miracle possible is the Gilmer "Timing®" Belt drive which Lear chose for the vital job of transmitting the power of the 3 hp. gasoline engine to the high-speed alternator.

This bantam power supply, occupying only 1½ cubic feet and weighing as little as 35 pounds, produces up to 1500 watts AC or 1350 watts DC. To achieve such efficiency the alternator is designed to operate at approximately *three times* the engine's 4000 rpm speed, or nearly 12,000 rpm! This means that the belt must travel at almost a mile a minute, even though very small-diameter pulleys are used.

For such an application no other type of drive of equal capacity can match the "Timing" Belt's lightness of weight, compactness, and ability to transmit full power at such high speed without slippage, without lubrication and without take-up or other maintenance! Lear's own literature points up these additional facts:

"Selected for its high efficiency, the flat tooth-belt drive assures a long, dependable operating life for both engine and alternator due to reduced radial bearing loads which this particular drive allows*. The belt is steel-cable-reinforced and will give long life and trouble-free service."

Your local NYB&P-Gilmer Distributor stocks standard "Timing" Belts and pulleys and will gladly help in obtaining special sizes you may require for original equipment. Consult your classified telephone directory for his name.



Larger 3500-watt Lear unit employs a compact 2"-wide Gilmer "Timing" Belt drive.

**Positive tooth grip replaces friction grip, eliminates need for initial belt tension, lightens bearing loads.*

Gilmer **V-BELTS AND "TIMING®" BELTS**

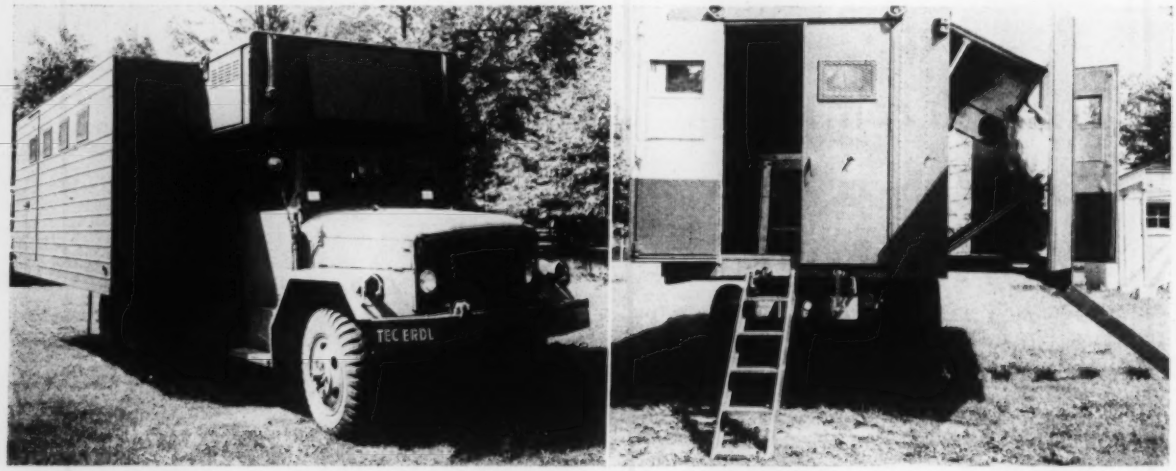
NYB&P INDUSTRIAL RUBBER PRODUCTS

NYB&P — Founded 1846 — NEW YORK BELTING & PACKING CO.

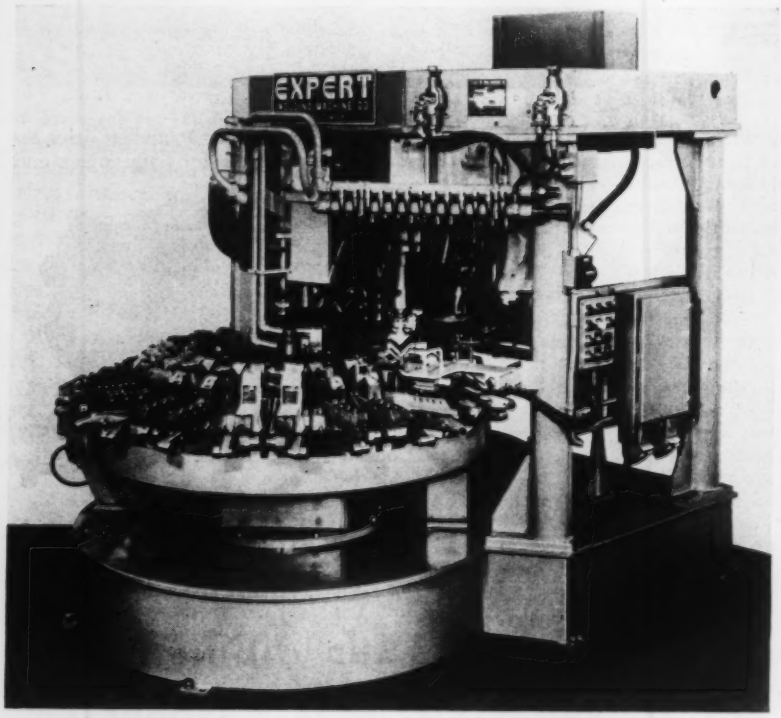
NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products

—ITEM 510—



ELBOW-ROOM FOR MAP-MAKING is provided by this new van body on a standard 2½-ton Army truck chassis. Developed by the Corps of Engineers' Research and Development Laboratories for mobile photomapping operations, the van can be expanded from 7-ft travelling width to 13½ ft by two men in less than 5 minutes. Side walls are built on outrigger beams extended by cranking. Hinged floor and roof panels are then swung into position and walls retracted to form weather-tight seals. Glass fiber windows are nonfrosting and have blackout panels. A photomapping company of an Army Topographic Battalion will have eleven expansible vans heated and air-conditioned to operate in a variety of climatic conditions.

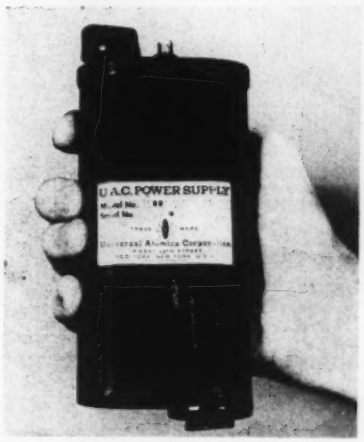


BUSY WELDER is this new 12-station machine developed by Expert Welding Machine Co. A cam drive running continuously at 5 rpm controls work sequence. The machine produces nine spot welds on 1200 two-piece automotive hood hinges per hour. Right and left-hand hinges are welded on adjacent fixtures around the 6-ft diam index table. A part detector checks each fixture for load condition at stations ahead of weld stations. The machine occupies 7 by 8 ft floor space and is 7 ft high.

AXIMAX II is this miniature cooling fan developed by Rotron Mfg. Co. Its rotor and air impeller are cast in one piece. Aximax measurements are 2-in. diam and 1½ in. length. It delivers 58 cfm at 20,000 rpm and has solder-type hermetic terminals which allow it to be used in a closed piping system.

Military production of jewel bearings is under test development at Elgin National Watch Co. Pilot production has been started on 26 automatic and semiautomatic machines developed by Elgin during the last six years. A spokesman for the company said that it hopes to develop production processes that would, in an emergency, be

the nucleus needed to build an effective domestic source of the gems, thereby averting a critical shortage such as that which existed during World War II. Jewel bearings are used in military timepieces, aircraft instruments, test gages and precision mechanisms.



COMPACT POWER SUPPLY has been introduced by Universal Atomics Corp. The transistor-equipped unit can produce 16,000 v dc from as little as 3 v dc input. Total weight is 1½ lb and dimensions are 1½ by 3 by 6 in.

Meetings

AND EXPOSITIONS

Aug. 15-17—

Institute of the Aeronautical Sciences. Turbine-Powered Air Transportation Meeting, to be held at the Grant Hotel, San Diego, Calif. Further information can be obtained from institute headquarters, 2 E. 64th St., New York 21, N. Y.

Aug. 21-24—

Western Electronic Show and Convention. Show headquarters, Pan Pacific Auditorium; Convention headquarters, the Ambassador Hotel, Los Angeles. Co-

(*Continued on Page 22*)

DRAFTING TRENDS

At Brede Inc., Minneapolis display firm, artist William Marshall uses Rotolite to save valuable time, prints layouts and floor plans for wide distribution.

Office size printer makes crisp copies, takes little space

Unusually compact and efficient, a new printing unit called "Rotolite" is now available for drafting rooms, shops and offices. Designed for quick copies or check prints, "Rotolite" is used with any standard development unit, blueprint or whiteprint.

Despite its streamlined size (the smallest model is 30″ wide, 7″ deep), "Rotolite" delivers sharp prints from any translucent original. The unit has a unique rotating light source from a 25 W fluorescent tube. Perhaps its biggest advantage is simplicity of operation—untrained people quickly learn how to use it. While no substitute for your normal reproduction service, "Rotolite" is ideal for urgently needed on-the-spot prints.

The sturdy "Rotolite" fits almost anywhere and sets up very easily. It attaches to a wall or works well on a desk or table. No installation is required; it simply plugs into any 115 volt AC outlet.

Available in 3 standard models, "Rotolite" can accommodate print widths up to 18″, 27″ or 42″ in any length. A dry-developing chamber is furnished as a standard accessory. Other developing units are available, semi-moist or wet. The complete unit sells for $129.50 up.

New extension tape rule gives readings from a dial

A unique extension tape called "Rulomatic" shows linear measurements in a Vernier dial. Easy to read and highly accurate, the self-reading tape gives fractional measurements to 1/16″.

The white face tape is counter-balanced with an inner return spring for smoother operation. Special pads are built into the case to clean and oil the blade each time it is used. Another unique feature: a serrated wheel scriber can etch the point to which measurements are made.

Chrome plated and highly polished, "Rulo-matic" sells for $3.25.

Further information on these items is available from the Reader Service Division of the Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT, & DRAFTING FURNITURE

GEARS *that keep* AMERICA *on the* GO!

In vehicles of almost every description—from boats to heavy farm machinery—you'll find flywheel ring gears, transmission gears, differential drive gears, and other gears that are designed, engineered, and manufactured by Automotive Gear Works.

If your product uses gears for power transmission, it may pay you to look into the popularity of gears manufactured by Automotive Gear Works—and learn how we serve as the "gear department" for so many leading manufacturers. Why not write today for further information?

DOUBLE DIAMOND TRADE MARK GEARS

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914 — RICHMOND, INDIANA

SUBSIDIARY OF EATON MANUFACTURING COMPANY

Reader Information Service

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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JULY 26, 1956

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CITY _____ ZONE_____

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MACHINE DESIGN
JULY 26, 1956

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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MACHINE DESIGN
JULY 26, 1956

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
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410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
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420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
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Please print plainly

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CLEVELAND, OHIO

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NEW KAYDON THIN-SHELL NEEDLE BEARINGS

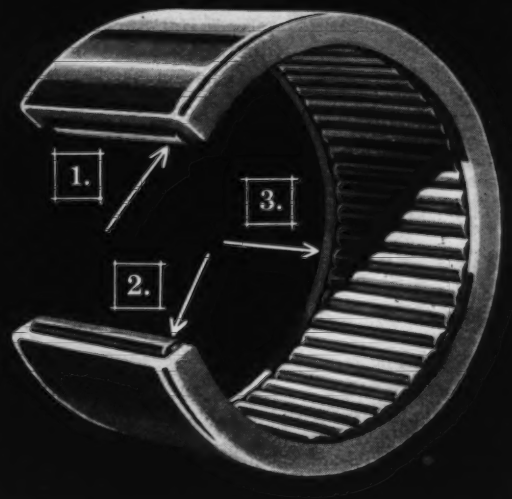
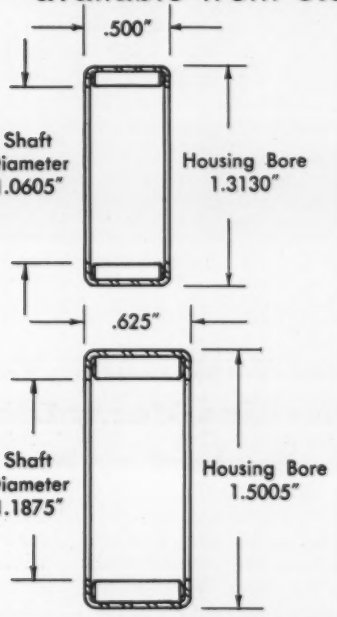


Illustration is 2-times actual size of needle bearing

Two standard sizes available from stock



You get these Kaydon design advantages:

1. **Greater effective length needle rollers for MORE CAPACITY (41% on ½" width)... LONGER LIFE (2.8 times as much on ½" width)**
2. **Simplified construction that SAVES you money**
3. **Pre-packed lubrication that SAVES assembly time**

HERE it is! Kaydon's new thin-shell needle bearing. A bearing that gives you more of everything — more capacity... more economy... *plus longer life* than any other comparable bearing, because of greater effective length of spherical end rollers.

This new bearing is ready for you right now from stock in two standard sizes (illustrated). Other sizes will be available later.

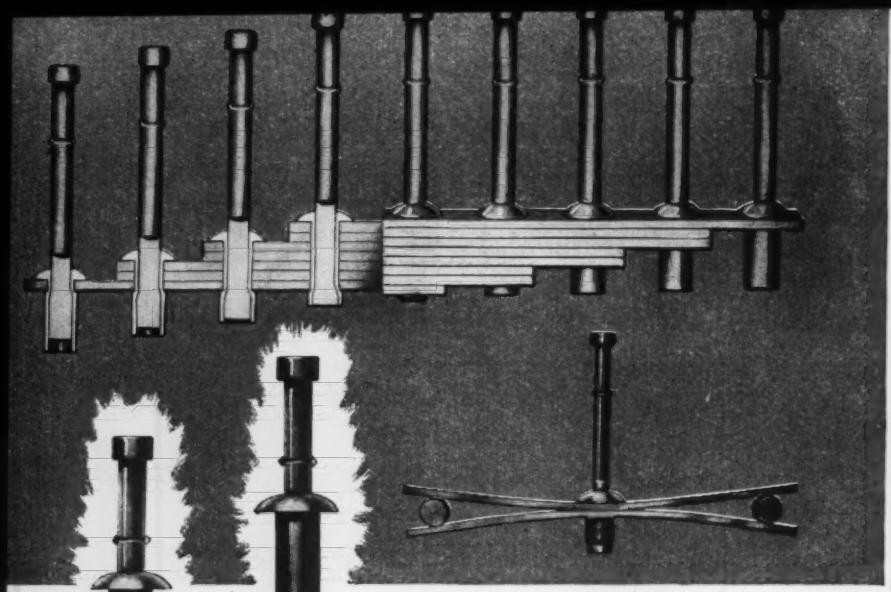
For complete specifications, ask for Data Sheet No. K562—write, call or wire Kaydon of Muskegon.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter... Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

—ITEM 513—



Excellent hole filling characteristics of Townsend Versa-Rivet are shown in cross section photo above. Test piece also demonstrates that various material thicknesses can be riveted successfully with rivets of identical length. Lower illustration shows high clinch attained with Versa-Rivet.

New Townsend Versa-Rivet Provides Versatile, Uniform Fastening Method

The hole filling qualities, wide grip range, high clinch, and positive stem retention now possible with the new Townsend Versa-Rivet give industry a uniformity of fastening never before available.

In the past, variations in hole diameter made it virtually impossible to completely fill the hole in every instance. This difficulty is eliminated with the Versa-Rivet which always adjusts to fill the hole and provides high stem retention.

The method of setting the Versa-Rivet also provides high clinch and makes it possible to use one length to fasten a wider range of material thicknesses. Positive inspection is easy since a properly set rivet is indicated by the amount of stem shoulder protruding above the rivet head.

The Versa-Rivet is available in the universal head with one length for each diameter. It is installed with standard Townsend rivet guns with controlled-stroke pulling heads and accessories.

A product of Townsend Research and Development Department, the Versa-Rivet has back of it over 100 years experience in the fastening industry. This organization has developed the widest range of types and sizes available in the industry. Townsend engineers have designed and built special purpose machines and developed techniques that make possible such innovations as the Versa-Rivet.

For technical data on how the Townsend Versa-Rivet will give you a more uniform method of fastening, write to Townsend Company, P.O. Box 237-E, New Brighton, Pennsylvania.

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Cherry Rivet Division • Santa Ana, California

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

News Roundup

(*Continued from Page* 15)

sponsored by the West Coast Electronic Manufacturers' Association and the Los Angeles and San Francisco sections representing the Seventh Region of the Institute of Radio Engineers. Additional information can be obtained from Wescon, 344 N. La Brea Ave., Los Angeles 36, Calif.

Sept. 7-9—

Metal Powder Association. Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information can be obtained from association headquarters, 420 Lexington Ave., New York 17, N. Y.

Sept. 10-12—

American Society of Mechanical Engineers. Fall Meeting to be held at the Cosmopolitan Hotel, Denver. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 10-13—

Society of Automotive Engineers. National Tractor Meeting and Production Forum to be held at Hotel Schroeder, Milwaukee. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 11-13—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from institute headquarters, 366 Madison Ave., New York 17, N. Y.

Sept. 11-14—

Packaging Machinery Manufacturers Institute. Packaging Machinery and Materials Exposition to be held at the Public Auditorium, Cleveland. Additional information can be obtained from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

Sept. 12-14—

Porcelain Enamel Institute. Annual Meeting to be held at the Broadmoor Hotel, Colorado Springs, Colo. Additional informa-

←ITEM 514

tion can be obtained from institute headquarters, 1145 19th St. N. W., Washington 6, D. C.

Sept. 16-22—

American Society for Testing Materials. Second Pacific Area National Meeting and Apparatus Exhibit to be held at Hotel Statler, Los Angeles. Additional information can be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

Sept. 17-21—

American Society of Mechanical Engineers. Instruments and Regulators Division and Instrument Society of America Exhibit and Joint Conference, to be held at the Coliseum, New York. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 17-21—

Instrument Society of America. Eleventh Annual International Instrument - Automation Conference and Exhibit, to be held at the Coliseum, New York. Additional information can be obtained from society headquarters, 1319 Allegheny Ave., Pittsburgh 33, Pa.

Sept. 17-21—

Illuminating Engineering Society. National Technical Conference to be held at Hotel Statler, Boston. Further information can be obtained from society headquarters, 51 Madison Ave., New York 19, N. Y.

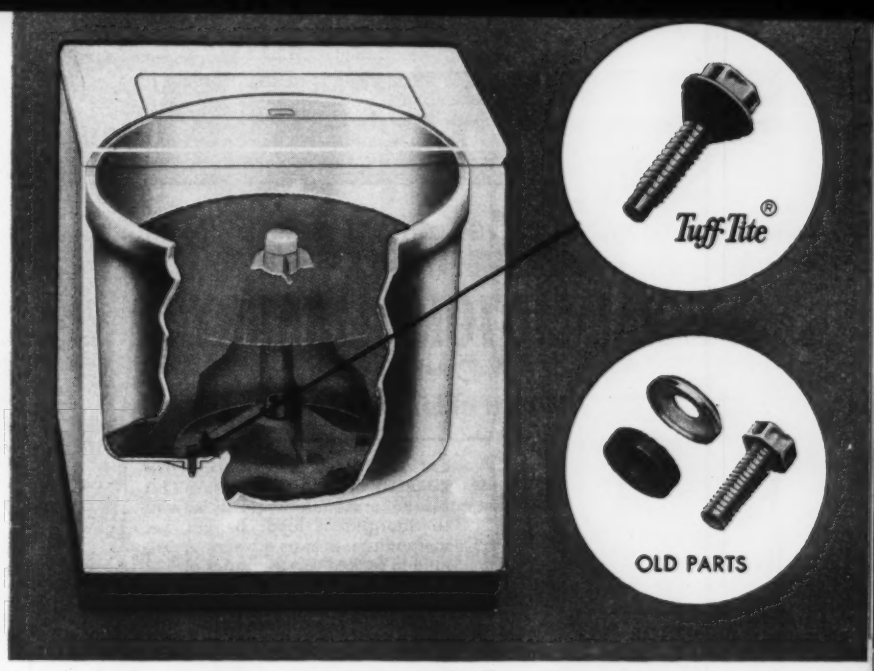
Sept. 23-26—

American Society of Mechanical Engineers. Petroleum - Mechanical Engineering Conference to be held at the Statler Hilton Hotel, Dallas, Tex. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 24-25—

Steel Founders' Society of America. Fall Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, O.

ITEM 515→



Townsend *Tuff-Tite*® Fastener Gives Leakproof Fastening... Protects Enamel On Washer Tub

A large manufacturer of domestic washing machines has found the solution to leakproof fastening of tub to frame with Townsend Tuff-Tite fasteners. Previously, a three-piece fastener had been used—bolt, metal washer and flat neoprene washer.

Now, the one-piece Tuff-Tite brass bolt and washer with the conical assembled neoprene washer shown above is doing the job.

The result—positive leakproof assembly—superior protection from chipping the porcelain enamel—greater resistance to loosening from vibration. Assembly has been speeded and triple inventory eliminated.

This achievement is made possible by the design of all Tuff-Tite fasteners. They have an undercut in the washer head which controls and traps the neoprene when the fastener is tightened. The neoprene is forced into the hole and around the threads to provide a cushion which protects the surface and forms a water-tight and air-tight seal.

Tuff-Tite fasteners are available with many types of screw and bolt shanks and head styles. They are made of carbon, alloy, and stainless steel, aluminum, brass and other metals.

To learn more about how Tuff-Tite can give you leakproof surface protection with economy, use the coupon below.

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Chicago Area Division • Santa Ana, California

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

TOWNSEND COMPANY
Post Office Box 237E
New Brighton, Pa.

Please send to me without obligation "Tuff-Tite" Bulletin TL-97.

Name_____ Title_____

Company_____

Street_____

City_____ Zone_____ State_____

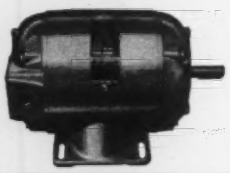
SAVE

on original development costs
by using REULAND ELECTRIC'S

SPECIAL-MOTOR "LIBRARY"

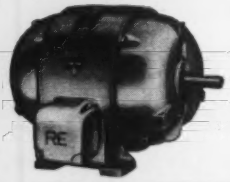
Over 900 Different
Electric Motors

MOTOR #810



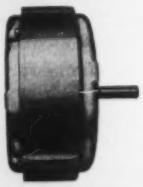
CAN BE STALLED OR "LOCKED" WITH CURRENT ON without damage. This torque motor automatically adjusts to intermittent load changes, yet maintains constant power. Available in locked service duties of 5%, 10%, 25%, 50% and 100% with maximum stalls of 5, 10, 20 or 60 minutes, *or continuous* stall.

MOTOR #569



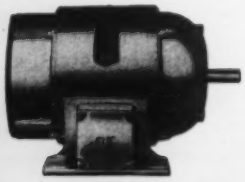
MULTI-SPEED MOTOR operates at different speeds as desired. Available in 2, 3 or 4-speed ratings in the following types:
Constant Torque—Constant torque regardless of motor's speed.
Variable Torque — For loads that maintain their own momentum.
Constant H.P.—Constant H.P. even at reduced motor speed.

MOTOR #617



WAFER-THIN, AIR COOLED, TOTALLY ENCLOSED. Originally designed for ventilation and air moving installations where it could be direct-connected to the fan *within* the piping or vent. Direct-fan attachment eliminates pulleys, belts, brackets and fan shaft. Can also be supplied in open type for mounting out of airstream.

MOTOR #402



HIGH STARTING TORQUE ON LOW STARTING CURRENT, plus variable speed are offered by the Slip Ring motor. Often permits using regular current for getting heavy loads up to full speed. Cranes, heavy fans, printing presses and crushers are typical uses. Available separately or with single or double reduction gear reducers.

REULAND'S "XPANDABLE" DESIGN MEANS ALMOST UNLIMITED ADAPTABILITY . . .

Don't pay for special motor development until you first check the Reuland SPECIAL-MOTOR LIBRARY. Reuland's revolutionary new XPANDABLE DESIGN idea has produced literally hundreds of unique power packages, one of which may already be the answer to your needs.

Reuland also produces a complete line of standard electric motors. Free engineering literature will be sent upon request. Your inquiry will be given prompt, personal attention.

REULAND ELECTRIC COMPANY
Distributors In All Principal Cities
Western Division: Alhambra 43, Calif. — Eastern Division: Howell 43, Mich.

MEN

OF MACHINES

Wallace S. Berry has been appointed director of research for the automotive division of American Motors Corp., Detroit. Mr. Berry had been chief mechanical engineer of the division. He was previously chief mechanical engineer for Nash Motors.

Clarence H. Beck has joined Lockheed's Missile Systems Div. in Van Nuys, Calif., as a design specialist in the research laboratory's flight test electronics department. Dr. Beck had been chief of the standards engineering department of Gilfillan Bros. Inc.

The appointment of **Frank A. Votta Jr.** as chief engineer has been announced by the Hunter Spring Co., Lansdale, Pa. Mr. Votta is rejoining Hunter after two years' association with Philco Corp.

Henry F. McKenney has been appointed vice president for engineering by Electronics Corp. of America, Cambridge, Mass. Mr. McKenney previously was chief engineer of the Ford Instrument Co., division of Sperry-Rand Corp.

Henry F. McKenney

Men of Machines

Fenwal Inc., Ashland, Mass., has announced the appointment of **E. Sohier Welch** as chief research engineer. He joined the company's research department in 1950.

Ernest L. Richmond has been appointed chief engineer by the Plainfield, N. J. division of Worthington Corp. Mr. Richmond has been associated with the company since 1945.

Webster Mfg. Inc., Tiffin, O., has named **C. S. Jones** vice president of engineering.

Louis G. Frank has been appointed chief engineer of the Aurora, Ill. plant of Caterpillar Tractor Co. He has been chief engineer of Trackson Co., a subsidiary of Caterpillar, since 1951. He joined Trackson in 1929.

Vickers Inc. has appointed **Duncan Gardiner** director of research and development. His headquarters will be in Vickers' new Engineering and Administration Center in suburban Detroit. Mr. Gardiner's previous affiliations were with Worthington Pump & Machine Co., Cadillac Motor Car Co. and the Detroit Edison Co. He joined Vickers in 1934 and was named chief product development engineer in 1948. He has been assistant chief engineer since 1950.

Duncan Gardiner

SHIMS

BRING YOUR SHIM PROBLEMS TO EXPERIENCED SPECIALISTS

Only LAMINATED SHIM COMPANY Offers These Efficient, Economical Solutions:

THE LAMINUM® SHIM

SIMPLY PEELS FOR ADJUSTMENT

Made up of from 3 to 63 layers of .002 or .003 inch brass or steel, metallically bonded together over their entire surfaces. No dirt between layers. Peels with penknife.

THE LAMISOL® SHIM

FOR QUICK, ASSEMBLY LINE USE

The laminations of the LAMISOL® Shim (in brass) are temporarily joined by spot-soldering on the edges. Gauges and number of laminations within one shim are unlimited.

PACKAGED SHIM STOCK

READY FOR EASY USE, WITHOUT WASTE

Thin gauge 6" x 100" rolls feed through package slots. Heavier gauges in flat envelopes. Available from your Industrial Distributor.

LAMINUM® and LAMISOL® Shims are also made of ALUMINUM; layers are .003".

FLASH! *LAMINUM® now available in STAINLESS STEEL with layers of .002" or .003".*

LAMINATED SHIM COMPANY, INC.

SHIM HEADQUARTERS SINCE 1913

Check Our Stampings Division For Your Stamped Parts Requirements

MAIL TODAY!

LAMINATED SHIM COMPANY, INC.
1207 UNION STREET, GLENBROOK, CONN.

Please send me more information on:

☐ SHIMS ☐ STAMPINGS ☐ BOTH

☐ *We'd like to discuss our problem with one of your Sales Engineers.*

NAME _____ TITLE _____

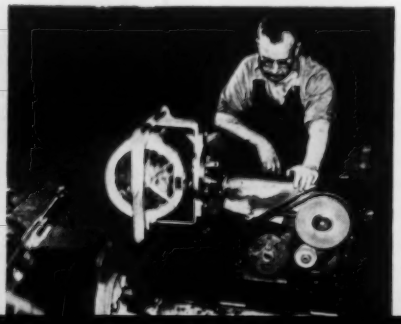
COMPANY _____

STREET _____

CITY _____ ZONE _____ STATE _____

20 Case Histories of G-E Motor Benefits

AMERICAN COOLAIR CORP.
"customers like 'no-reoiling' feature"



RED DEVIL TOOLS
"stands up under severe vibration"

CAMPBELL-HAUSFELD CO.
"makes product easier to sell"

BUCKEYE INCUBATOR CO.
"customers say 'they're dependable'"

TRUFLOW FAN COMPANY
"never had a motor failure"

UTILITY APPLIANCE CORP.
"virtually trouble-free service"

BERKELEY PUMP CO.
"lighter weight, modern appearance"

GENERAL WIRE SPRING CO.
"more than adequate power reserve"

W. M. CISSELL MFG. CO.
"easier to handle and install"

PENBERTHY INJECTOR CO.
"allows maximum design flexibility"

A. P. RUTH & CO., INC.
"speeds assembly, saves on shipping"

PERMUTIT COMPANY
"saved $8 per unit"

XU

s—HOW MANY APPLY TO YOU?

METALMASTER CORP.
"wide customer acceptance"

MASTER-BILT REFRIG. MFG. CO.
"standardized 100% with G. E."

AMERICAN DUPLEX CO.
"unexcelled durability"

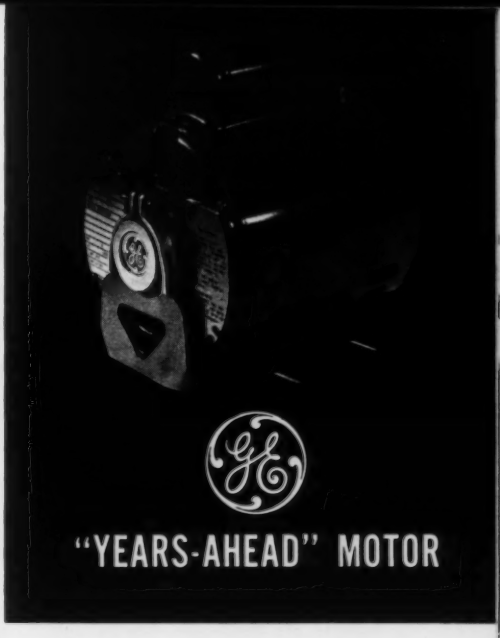
GOLD MEDAL PRODUCTS CO.
"saved 18% in shipping costs"

C. M. SORENSEN CO., INC.
"reduced weight 15%"

ALVEY CONVEYOR MFG. CO.
"all-angle mounting sold us"

MOUNTAIN STATES EQUIP.
"cut weight nearly 10 lbs."

TAIT MANUFACTURING CO.
"neater, more compact"



"YEARS-AHEAD" MOTOR

THESE G-E FHP MOTOR FEATURES ENABLE YOU TO IMPROVE YOUR PRODUCT, YET CUT COSTS

The twenty case histories at left are typical of the profit-building experiences of thousands of manufacturers using General Electric motors. The reason is simple—only G.E. gives you *all* of these outstanding features, combined into a complete line of smaller, lighter motors.

1. SMALLER, LIGHTER DESIGN—The trend to modern appearance and portability is reflected in this General Electric motor. It's 40% smaller, 50% lighter than old-style designs.

2. MYLAR* POLYESTER FILM INSULATION—It has over 35 times more moisture resistance, 8 times more dielectric strength than ordinary paper insulation.

3. ALL-ANGLE OPERATION—General Electric's all-angle lubrication system gives you positive lubrication regardless of mounting position. As a result, you can often avoid the higher cost of "special" motors.

4. EASY CONNECTION—A speed nut welded inside the motor shell permits fast, easy connection of conduit fitting.

5. MOUNTING VERSATILITY—This G-E motor, whether resilient or solid-base, can be rotated inside its cradle to obtain complete mounting versatility. The cradle may also be removed entirely to meet your design needs.

6. DOUBLE LUBRICATION LIFE—The General Electric combination of a larger oil capacity (50% more than old style designs), and an efficient oil retention system means minimum motor maintenance for you.

Thousands of manufacturers have already used millions of these "Years-ahead" G-E motors. Why not evalute your own motor savings in terms of these G-E motor benefits?

For more information, contact your nearby G-E Apparatus Sales Office, or write Section 702-29, General Electric Co., Schenectady, New York.

** DuPont registered trademark.*
†Feature of G-E summer cooling fan motors.

GENERAL ELECTRIC

Same filter capacity in 1/5th the space!

That's the advantage Cuno's new, 40-micron SUPER Auto-Klean has over a replaceable-cartridge-type filter!

. . . and you can clean this 40-micron filter simply by turning the handle.

Five to six times smaller in volume than comparable cartridge-type filters of equal capacity, Cuno's new SUPER Auto-Klean® is easy to integrate into new or existing engines, machine tools, or industrial machinery.

It provides positive protection against solid particles larger than 40 microns (actually 0.0015 in.) in lubricating oil, hydraulic fluid, coolant, or other industrial fluids. Here are other features it offers the machine designer:

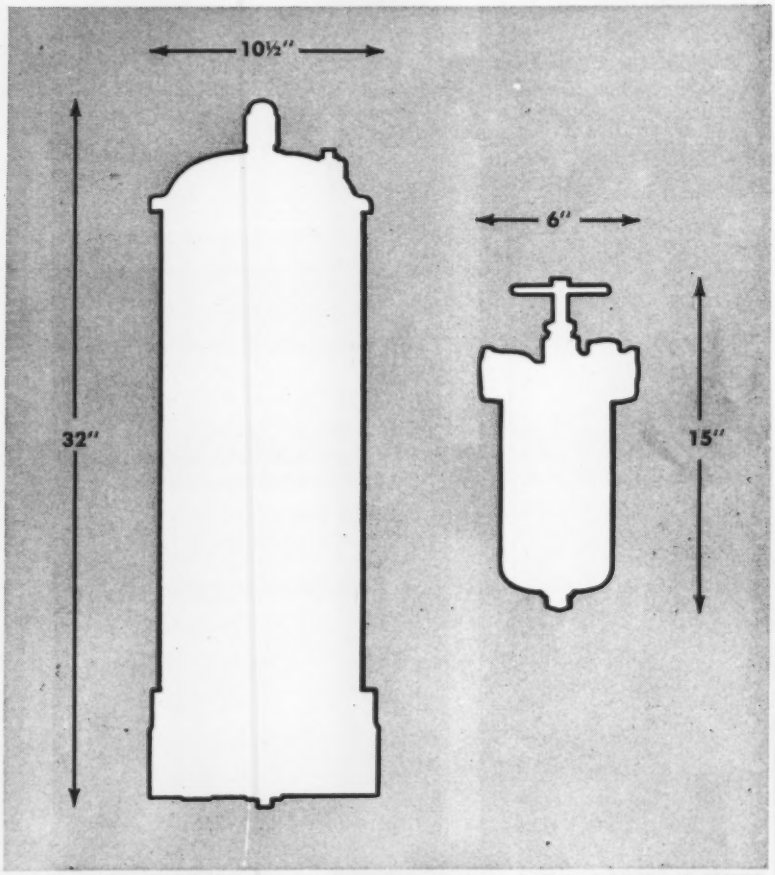
1. Easy cleaning. Just turn the handle—by hand or continuously with motor drive. No interruptions for cleaning.

2. No cartridge changes. Ends operating costs if you've been using cartridge type filters.

3. Low pressure drop, no pressure drop build-up. An 8- by 2¼-in. SUPER Auto-Klean element filters 30 gpm of 200 SSU oil with only .3 psi pressure drop—up to 75% more with slightly higher pressure.

4. Easy to build into new equipment. Standard housings and types available for a variety of mounting designs—in-line housings, flange mounting with external or internal piping. Mounts in any position in sump or reservoir.

5. Easy to install in old equipment. Fits existing Auto-Klean housings. You can easily replace most 2¼-in. diameter elements with SUPER Auto-Klean for finer, more effective filtration.



FIVE TO SIX TIMES SMALLER than equal-capacity cartridge-type filter *(left)*, Cuno's SUPER Auto-Klean *(right)* is ideal for micronic filtration of lube, fuel, hydraulic fluid, coolant in compact engines or machine tools.

Get complete information on this latest and best filter for *your* machine design. We're saving a free copy of SUPER Auto-Klean Catalog No. SAK-057 for you. Write for it today to Cuno Engineering Corporation, 14-7 South Vine Street, Meriden, Connecticut. 5.12

CUNO **ENGINEERED FILTRATION**

REMOVES MORE SIZES OF SOLIDS FROM MORE KINDS OF FLUIDS

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)

—ITEM 519—

For More Information Circle Item Number on Yellow Card—page 19

Specify

ALLEN STAINLESS

. . . for bright, lustrous finish

. . . for high resistance to corrosion

When designs call for bright finish and ability to stand up to corrosion, you'll find the largest range of sizes in Stainless Cap Screws available anywhere right at your Allen Distributor's. He stocks 97 standard sizes in Type 18-8 Stainless Steel, from #4 x 1/4" to 5/8" x 3" with NC threads; #10 x 3/8" to 3/8" x 1 1/2" with NF threads. Diameters of No. 8 and above have genuine unthreaded Allen Leader Points, to permit easier starting. Regularly furnished with Smooth Head unless Grip Head is specified.

ALLEN

MANUFACTURING COMPANY

Hartford 2, Connecticut, U.S.A.

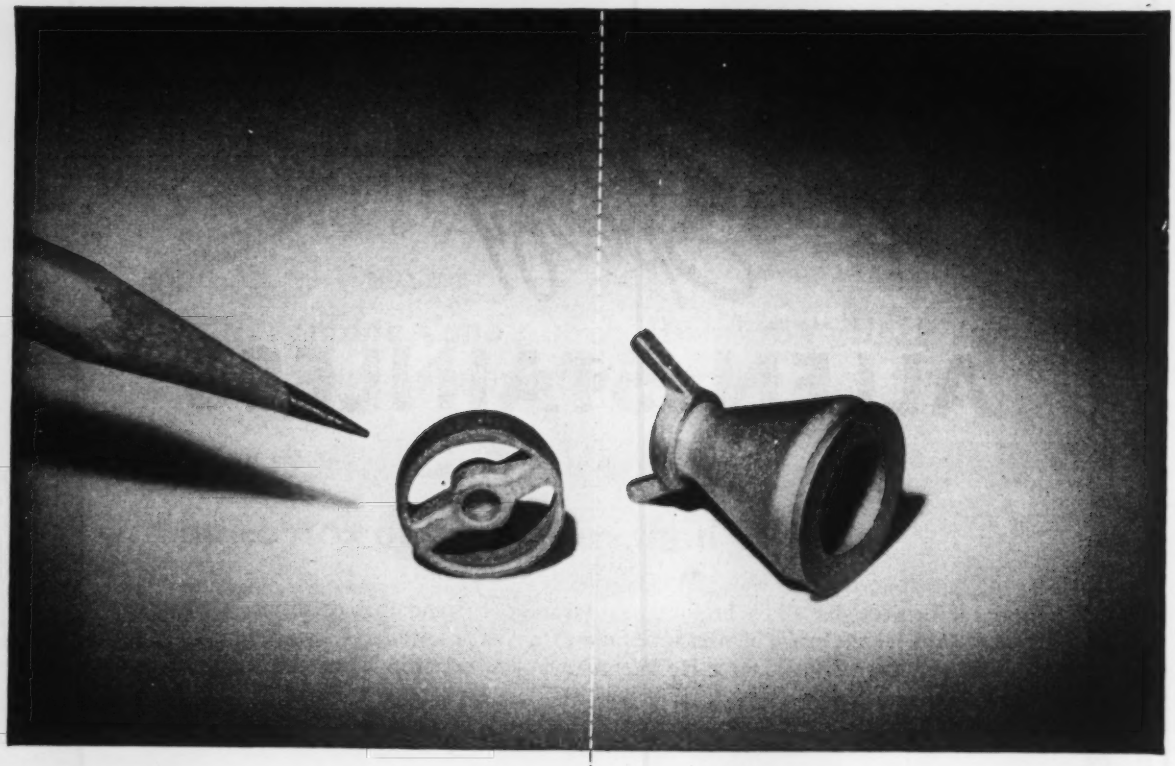
STAINLESS SET SCREWS

with the deep-driving, tight-holding ALLENPOINT stocked by your Allen distributor in 54 standard sizes from #4 x 1/8" to 1/2" x 1" NC threads; #10 in lengths from 3/16" to 3/4" NF threads.

Sold only through leading Industrial Distributors.

—ITEM 520—

For More Information Circle Item Number on Yellow Card—page 19



30% Saving American Machine and Metals, Inc., of Sellersville, Pa., manufactures the AutoBAR liquor dispensing system. This collet head is part of the locking mechanism.

15% Saving This collet spreader is used to lock the assembly in the neck of the bottle. Both parts shown above are twice life-size.

How Inco Precision Casting Cuts Costs

Look at these two small parts. Important to the AutoBAR liquor dispensing system, they are precision investment cast. But this wasn't always so —

When the collet head was machined from Inconel* nickel-chromium alloy bar stock it required ten costly operations—and about half the bar was machined away as scrap. Now Inco precision cast, it needs only lapping and drilling of one hole—cutting cost 30%!

And the collet spreader, when machined from bar stock, required three parts which had to be brazed together. It is now precision cast in one piece requiring only drilling and lapping one hole — cost is cut 15%.

On both parts a tolerance of plus or minus .003 inch per linear inch was held! Unusually close tolerances like this often can be held on small parts by Inco precision casting specialists.

All metal parts that come in contact with the liquor are made of Inconel nickel-chromium alloy or "K"* Monel age-hardenable nickel-copper alloy to protect color and flavor.

Can You Cut Costs with Inco Precision Castings?

Whenever you have a part which is 6 inches x 5 inches or smaller, weighs under 3 lbs., requires starting tolerances as close as plus or minus .005 inch per linear inch, and needs 5 or more fabrication steps, there's a good chance you can save by having it precision cast.

* * *

What Alloys Can Be Precision Cast?

You may obtain precision castings from Inco in many metals and alloys from plain carbon steel to the new super alloys. And no matter what metal you specify, you get many advantages.

*Registered Trademark

5 Advantages of Inco Precision Castings

- **Save up to 60% of production costs.**
- **Longer life with harder alloys.**
- **Little or no machining required.**
- **Wider design latitude.**
- **Higher alloys at lower cost.**

Get This Helpful New Booklet

Trying to keep costs in line on some small part? Then write for new 16-page booklet, "Cast to Outlast." Contains many case histories detailing how others cut costs with Inco precision castings. There is a good chance this helpful data will suggest a practical way to cut your costs, too.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

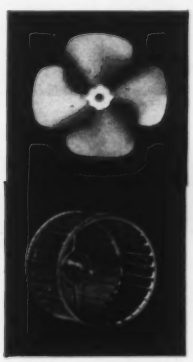
INCO TRADE MARK Nickel Alloys

Inco Castings . . . Precision, Sand, Centrifugal

THE BIG WIND

Now available nationally: complete line of large-diameter high-capacity Center-Lock Airotors *designed* to meet the most rugged requirements of today's major producers of air-moving equipment. This important Torrington development introduces an entirely new principle of blower wheel construction. *The center disc is dovetailed under pressure into the encircling blades. As a result, the interlocking joint tightens under centrifugal force, thus eliminating blade rattle and angle warp at high speeds.*

The new Center-Lock Airotor is available in diameters of 9½, 10⅝, 12⅝ inches, in both full and three-quarter widths; delivering up to 7000 cubic feet per minute. The advanced engineering behind this announcement is responsible for half a million design variations of air impellers contributing to the whirlwind success of products valued at nearly 4 billion dollars a year... Quite a breeze! Your inquiries are invited regarding applications and advantages of the new Torrington Center-Lock Airotor—the Big Wind in the big business to come.



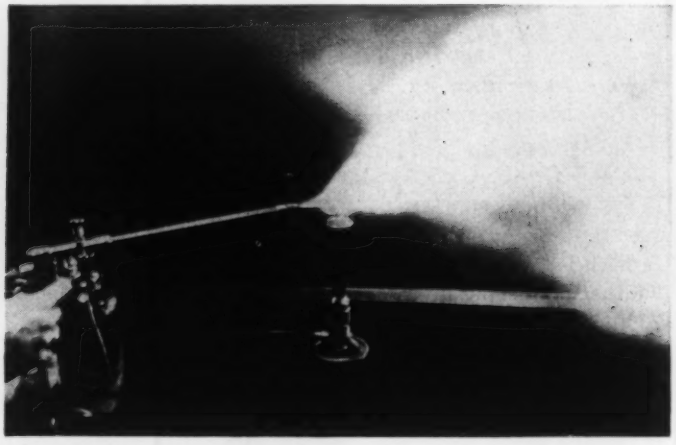
THE
TORRINGTON
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT
VAN NUYS, CALIFORNIA · OAKVILLE, ONTARIO

—ITEM 521—

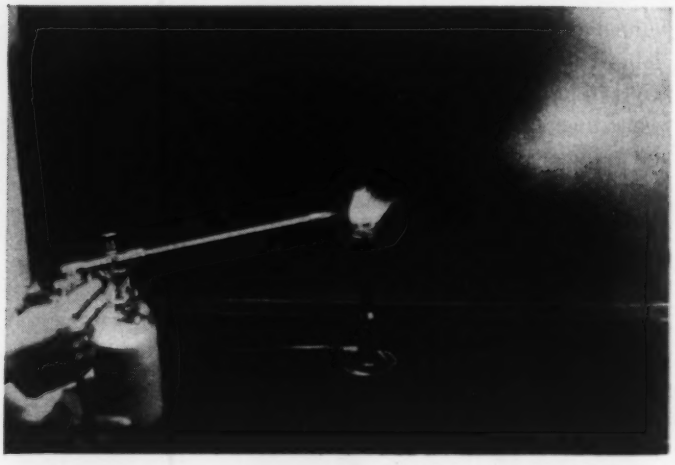
Announcing...the First

HYDRAULIC

Flame tests prove its fire-snuffing ability



This photo shows the instant combustion taking place when a conventional hydraulic oil of mineral oil type is atomized over a Bunsen burner.



In this photo, Shell Irus Fluid 902 replaces the mineral oil. Note that there is no ignition.

SHELL IRUS FLUID 902

Oil-Base fire-resistant FLUID

SHELL IRUS FLUID 902

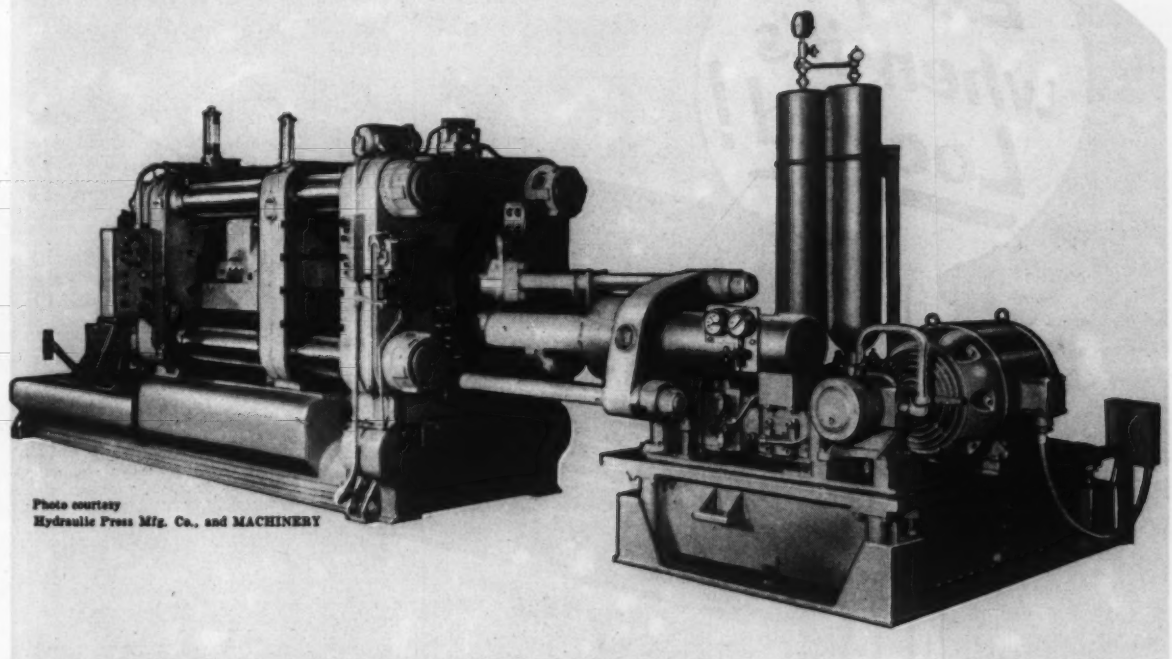


Photo courtesy Hydraulic Press Mfg. Co., and MACHINERY

AFTER THREE YEARS of intensive research, field application and evaluation, Shell Irus Fluid 902 is now commercially available for use in industrial hydraulic systems. While its cost is far lower than other fire-resistant fluids, its performance is comparable.

No major modification of equipment is necessary. Shell Irus Fluid 902 is a special formulation containing no corrosive ingredients . . . no adverse effect on seals or fittings. It is a direct replacement for hydraulic oils now in service.

Noncorrosive, and nonrusting. Steel and copper panels immersed in Irus Fluid 902 for one week at 160°F have shown no significant signs of corrosion. Rusting has not been a problem in long-continued field tests.

This is an efficient fire-snuffing hydraulic fluid that can be widely used. Send coupon for details.

SHELL OIL COMPANY

50 WEST 50 STREET, NEW YORK 20, NEW YORK

100 BUSH STREET, SAN FRANCISCO 6, CALIFORNIA

SHELL

SHELL OIL COMPANY
50 West 50th St. New York 20, N. Y. or 100 Bush St. San Francisco 6, Cal.

Please send me test data and information on Shell Irus Fluid 902.

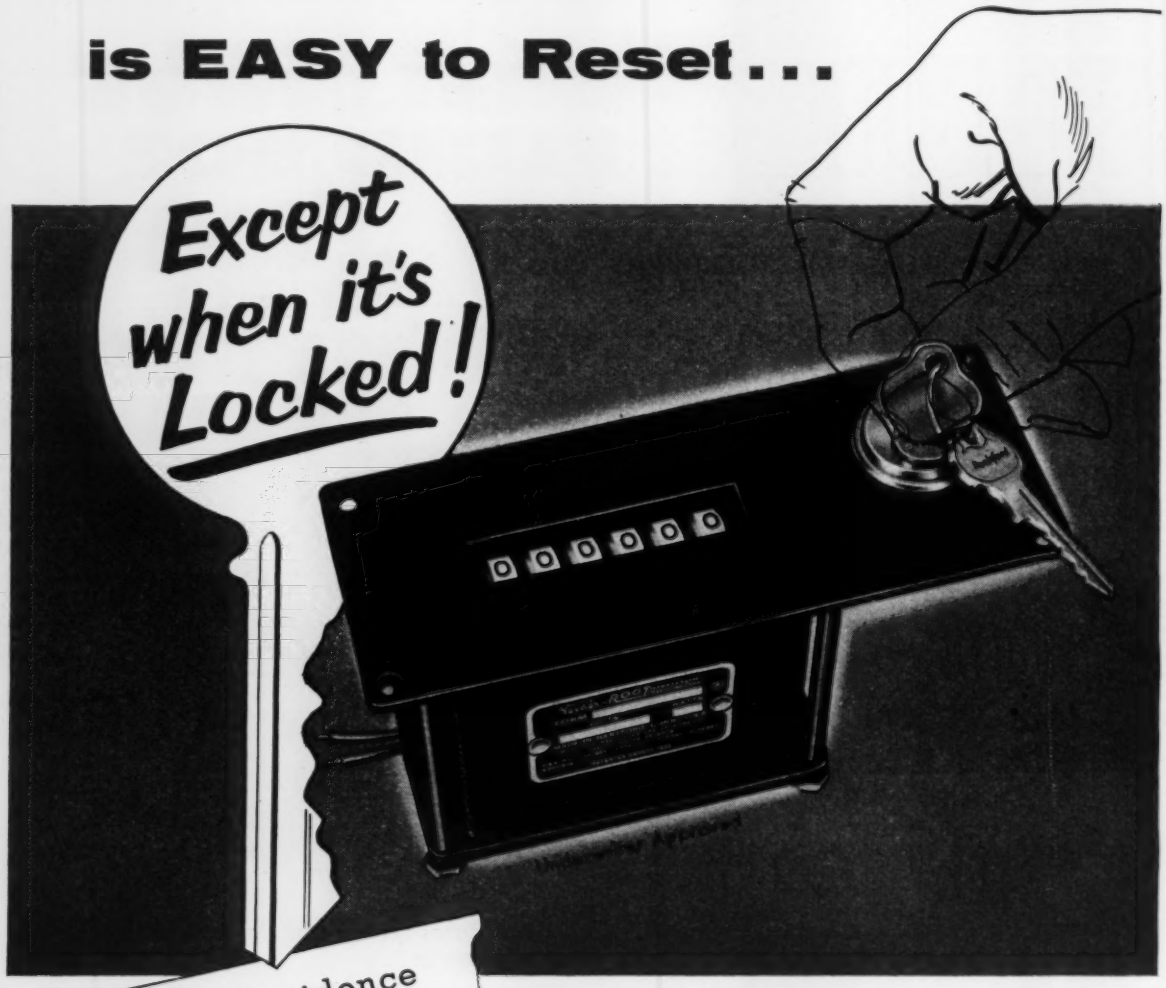
Name_____

Company_____

Address_____

—ITEM 522—

This NEW Magnetic Counter is EASY to Reset...



Added Evidence that—

Everyone Can Count on VEEDER-ROOT

Designed for panel mounting where remote indication is required, this electrically operated counter is a compact package 5.5″ long, 2.1″ wide, 2.7″ high. Capacity: 1,000 counts per minute. Power consumption, 8 watts. Stocked in 110 and 220 AC and DC. Easy to reset, except when locked . . . then the sturdy tumbler-lock* puts the damper on tampering. Yet one turn of the key resets all 6 figures to zeros.

This new Magnetic Counter is one of the thousands of Veeder-Root standard and special counters . . . electrically, mechanically and manually operated . . . in daily use throughout the world in industry, business, science and medicine. You, too, can count on Veeder-Root . . . to help you count anything you need.

*National Lock Co. Lock No. 68-4837; Key D-428

Stocked at
Hartford 2, Conn. • New York 19, N. Y.
Greenville, S. C. • Chicago 6, Ill.
Montreal 2, Canada
Offices and Agents in Principal Cities

VEEDER-ROOT
"THE NAME THAT COUNTS"

—ITEM 523—
For More Information Circle Item Number on Yellow Card—page 19

now available from Trent–

Titanium Tubing

For processing lines carrying fluids of an extremely corrosive nature — look to *Contour Trentweld* titanium tubing for reliable service.

This titanium tubing is completely uniform throughout any cross-section. The weld zone is free from bulging weld bead because Trent's exclusive process — performed with the weld area at the bottom — forms the molten weld metal into the shape of the tubing.

And, with titanium, you get the unique advantages of a tubing that's strong as steel but 44% lighter . . . virtually immune to a broad spectrum of corrosive materials . . . entirely free from stress-corrosion cracking.

So, next time you need a strong, light, extremely corrosion-resisting tubing—try *Contour Trentweld* titanium tubing. And remember, it's made by Trent — tube mill specialists.

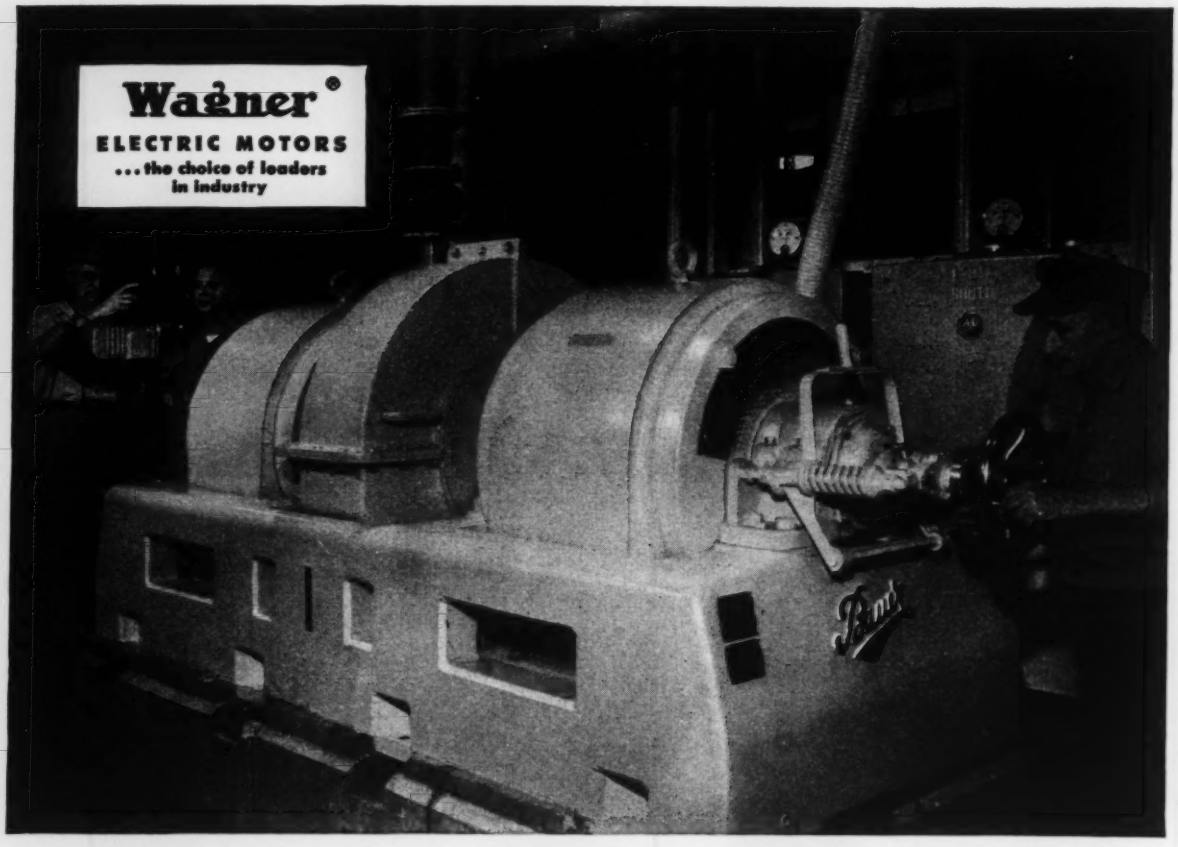
CONTOUR TRENTWELD

Stainless and High Alloy Welded Tubing

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)

—ITEM 524—

For More Information Circle Item Number on Yellow Card—page 19



Wagner Increment Start Motors Cut Initial Motor Costs... Cut Pattern Costs for Machine Manufacturer!

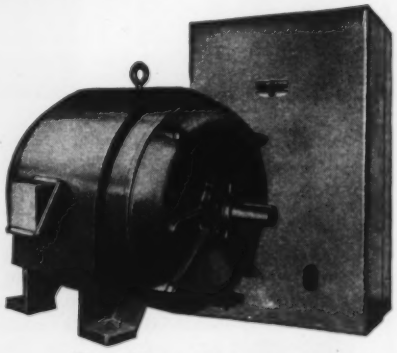
Recently the A. E. Staley Manufacturing Company placed an order with the Bauer Brothers Company for four double disc starch refiners, each requiring two 200 hp motors. The customer specified motors with auto-transformer starters to protect his plant's power distribution system.

Then a Wagner man stepped into the picture.

He showed both the Bauer Company and their customer how they could effect substantial savings through the use of Wagner Motors with Increment Starters which are far less expensive than motors with primary resistance or auto-transformer type starters... yet fully meet the polyphase motor starting recommendations of AEIC-EEI-NEMA.

Through co-ordinated engineering between Bauer and Wagner, stators, frames and rotors were furnished to Bauer, who made and assembled the endplates. The Wagner design permitted the use of identical endplate castings on both ends of each motor, and cut pattern costs.

Why don't you investigate the possibilities for savings by using Wagner Increment Start Motors on your big jobs? Your nearby Wagner engineer will help you select the increment motor and starter combination that meets your requirements. Call the nearest of our 32 branches or write for Bulletins MU-128 and MU-195.



Type RP polyphase motor in ratings to 400 hp with increment type starter

Wagner Electric Corporation
EST. 1891

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo., U. S. A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

H56-8

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS–AIR AND HYDRAULIC

—ITEM 525—
For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 526→

ingenuity of designers never ceases to amaze

Alcoa's Up-to-Dater on Impact Extrusions

News in four pages concerning rules for selecting impacts, finishing techniques, alloy selection, forward-reverse-sideward impacts and some impossible jobs. All solid stuff with very few commercials for tomorrow's design supervisors.

Rules of thumb in lieu of hunches

In the past 35 years of making impact extrusions, we've seen some lulus. Some we thought couldn't be made. Some were new applications and forms that we had never thought of. The ingenuity of designers never ceases to amaze us.

Some of these designers were so familiar with impacts that they just naturally considered them every place where they could save money. Others just had a hunch. Still others tried every other way before they hit on impacts. We don't want you to have to guess. And we certainly don't want you to have to try other fabricating methods. So here are some rules of thumb to help guide your thinking.

1. Parts requiring hollow sections—either tube- or can-shaped with one end closed.
2. Parts with walls or surfaces requiring zero draft.
3. Parts requiring lengths up to eight or ten times the diameter.
4. Parts requiring the strength of forgings.
5. Parts requiring tolerances down to ± 0.005".
6. Parts requiring ribs, bosses or fins as integral parts.
7. Parts requiring low unit cost in mass production. (Often the savings in machining, fabrication and assembly made by impacts amortize tooling in relatively short runs.)

Where the finish affects the start

There are lots of products that can't go to market unless they've been painted or plated or colored in some manner. Thus, the finish is an important consideration right from the start, and the manufacturing process is often selected on the basis of smoothness of surface. To this end, we point with pride to the smooth texture of Alcoa Impacts. No parting line. No scale. No draft to cut off. Just a lustrous, rustproof surface of about 125 micro-inches, on the average. To this, many manufacturers add paint or lithographed inks (look at tooth-paste tubes). Others anodize in every color of the rainbow.

we point with pride to the smooth texture

advertisement

Forward — Reverse — even Sideways

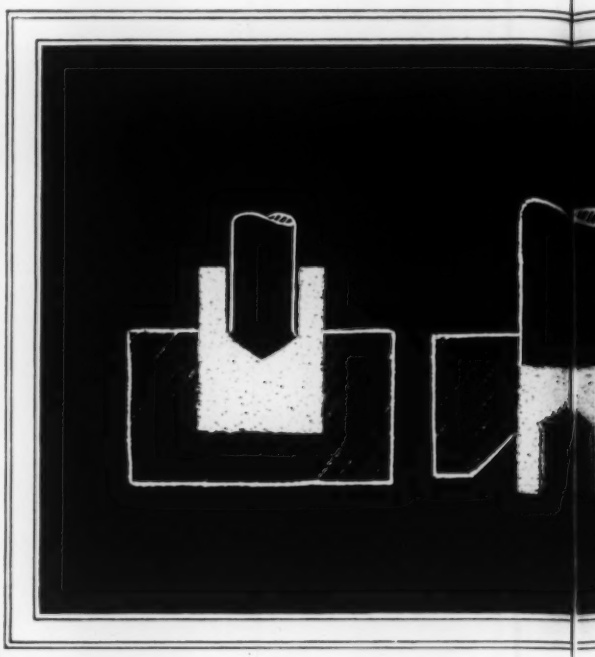
The first contact most designers have had with impact extrusions has been the reverse type. In this method, a metal slug is put in a closed die and struck with a punch. The metal squirts through the annular opening between the punch and the die, following the contour of the punch. This process has been called indirect extrusion, upward extrusion, backward extrusion or reverse extrusion. The last is best known and most accepted.

It is also possible to squirt the metal forward, through the die. Flanged parts with hollow or solid stems are made most economically by this method. This process, too, has lots of names: Hooker process, downward extrusion, direct extrusion and forward extrusion. Here, again, the best-known and most accepted terminology is the last.

Now hang on. It is possible to combine a forward and reverse extrusion in the same place. This forms a part, hollow on both ends and solid in the middle. Like other impacts, it may have flutes, splines and bosses both inside and outside. The parts may be round, oval, square, rectangular or odd-shaped, and either symmetrical or nearly symmetrical about the longitudinal axis.

Still with us? Not only can we impact forward and reverse, at the same time, but we can also go sideways, too. Thus, it is possible to make parts with a central hub having arms or spokes radiating from it. These arms or spokes may also be varied in cross section. Sideways impacts cost more, but designers often are confronted with problems of producing a lot of such pieces. Usually such shapes as impacts would be cheaper than assembly and fabrication.

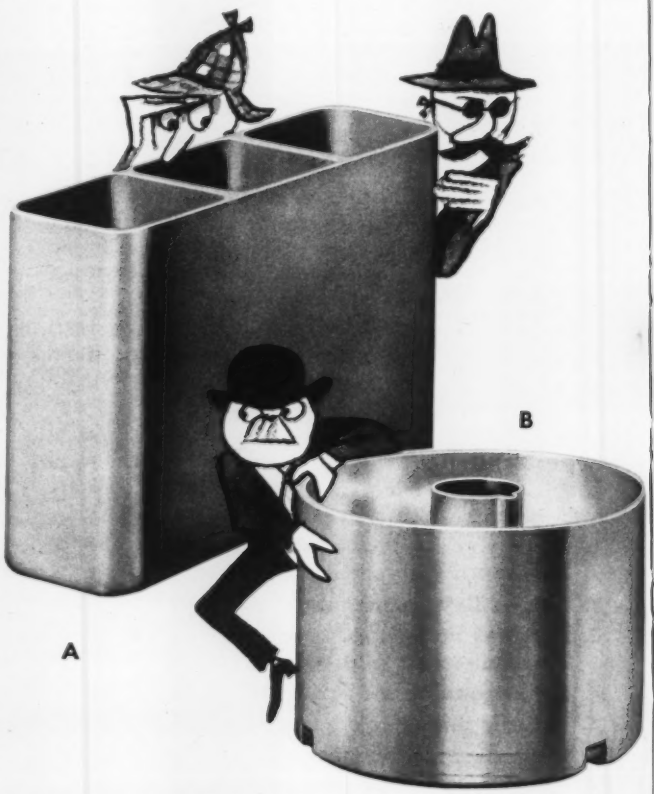
All of the foregoing should suggest to you that there is more than one way to bang out an impact. The best rule to follow is to suspect any closed-end tubular part or can-shaped part as susceptible to impact extrusion. And the best place to confirm those suspicions is at your local Alcoa sales office.



more than one way to bang out an impact

Some impossible jobs and a few difficult ones

Sounds like kidding, but many of the impacts you see across the bottom of these two pages would have made our production experts flip on edge ten years ago. Some still don't believe they are real. It's getting so that high-strength impacts of 7075 alloy and double-walled parts are downright commonplace. Asymmetrical parts are getting more common day by day. Forward-reverse combinations are old hat around our shop. More thinking is going into sideways impacts. Is all this well known among designers? On the chance that an idea may be lurking somewhere, check the five examples at the right.



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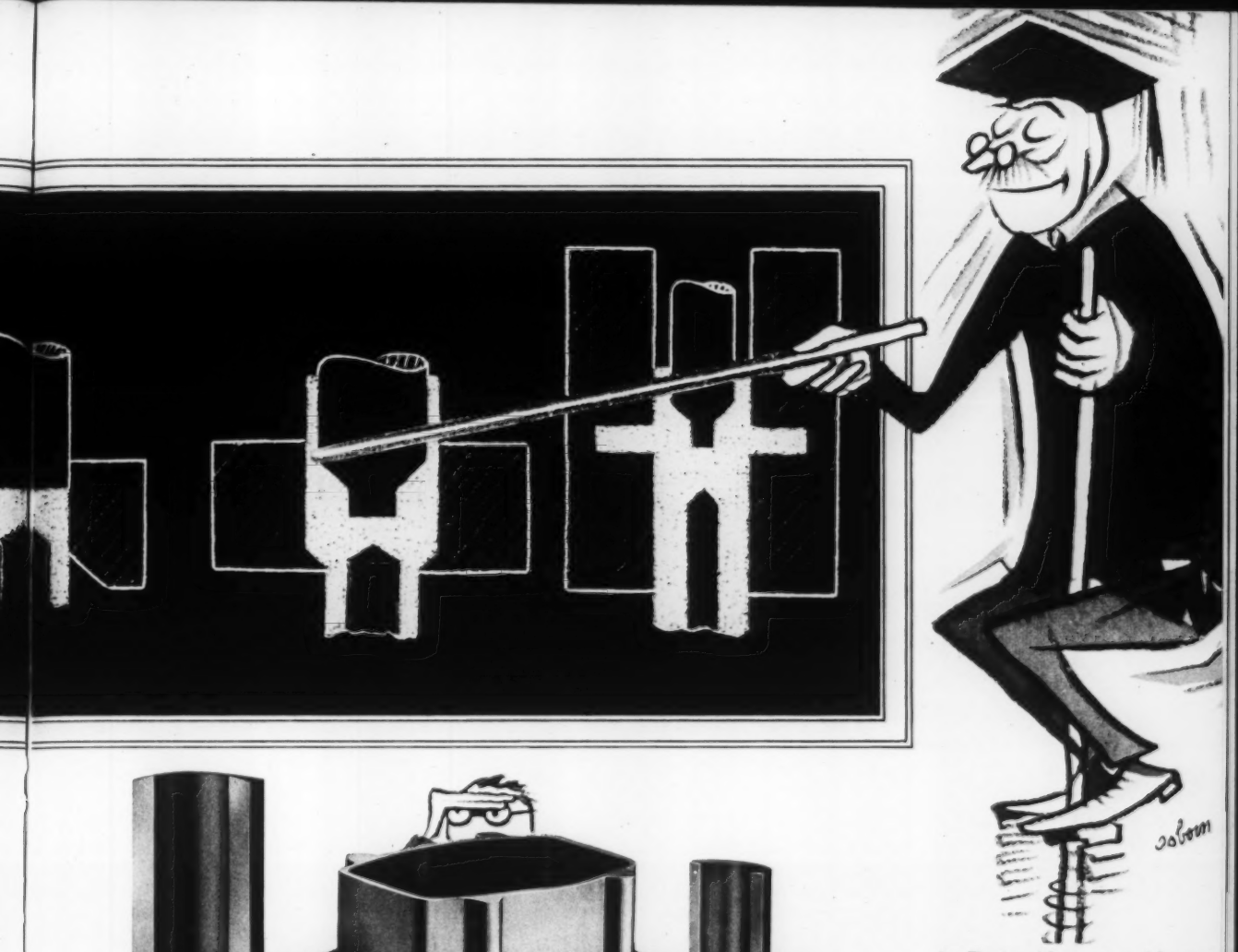
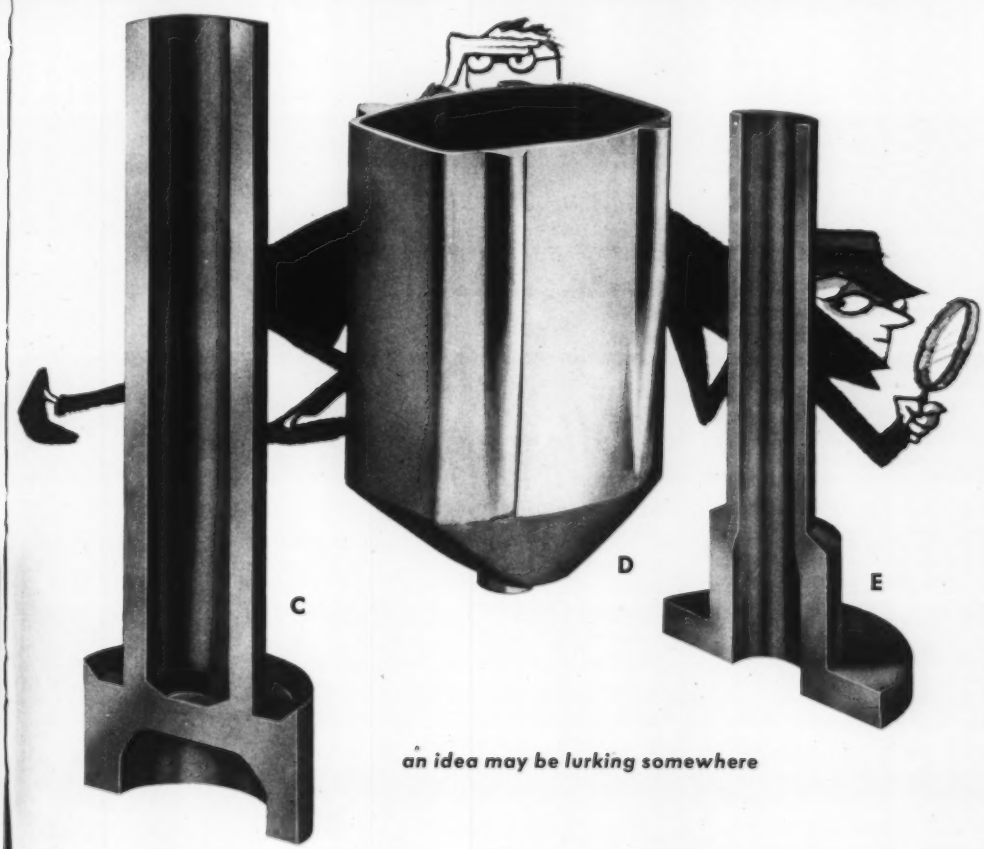




an idea may be lurking somewhere

A—Rectangular can with two internal partition walls is a cost saver. Formed in one shot as an impact, it would be extremely costly in other methods of fabrication or assembly.

B—Center-tube shell with thin side walls and heavy base is one-piece, seamless impact. Groove in center tube and fastening notches in base are integral. Unit is produced quickly and inexpensively compared to machining or welding.

C—Machining time and metal scrap would be extremely high if this finished part (shown sliced) wasn't made as an impact.

D—Tapered ribs, tapered and internally double-shouldered base and outside boss are all made at once in this special shape impact extrusion. Formed with 0° draft in walls, it would be highly expensive in any other process.

E—Four thicknesses of wall and a midway flange make this newsworthy. It is an excellent idea-starter of the way Alcoa Impacts can solve difficult problems of fabrication. Let us try on your problem.

advertisement

Alcoa's Up-to-Dater on Impact Extrusions (continued)

is for alloy

In the alphabet of design, one of the first considerations is alloy selection. Designers have definite ideas about the tensiles and yields they need. They reconcile these requirements with the suitable types of fabrication available—and base their decision on the economies of the problem. In impacts, Alcoa offers six alloys with varying properties up to 75,000 psi tensile.

Naturally, the stronger alloy impacts cost more . . . but often they're worth it. Here is a quick run down arranged in ascending order of mechanical properties.

MINIMUM MECHANICAL PROPERTIES OF WROUGHT ALUMINUM ALLOYS COMMONLY USED IN ALCOA IMPACTS

ALLOY AND TEMPER	TENSION				HARDNESS①
	WALL THICKNESS	ULTIMATE STRENGTH LB/SQ IN.	YIELD STRENGTH (SET=0.2%) LB/SQ IN.	ELONGATION PER CENT IN 2" OR IN 4D	BRINELL 500-KG LOAD, 10-MM BALL
1100-H152②	All	18,000	.....	....	...
1100-F③	.....	.....	.....	....	...
3003-F③	.....	.....	.....	....	...
6151-T6	All	44,000	37,000	7.0	90
6151-T84	.040"-.093" .094" & Heavier	35,000 38,000	32,000 35,000	4.0 4.0	80 80
6061-T4	All	26,000	16,000	12.0	50
6061-T6	All	38,000	35,000	7.0	80
6061-T84	.040"-.093" .094" & Heavier	35,000 38,000	30,000 35,000	4.0 4.0	75 75
2014-T4	All	55,000	32,000	10.0	100
2014-T6	All	65,000	55,000	7.0	125
7075-T6	All	75,000	65,000	7.0	135

①Hardness test will be made only on the bottom of the part. It is used only when a standard-type tension test specimen cannot be obtained from the side wall.

②This temper designation applies only to parts that permit selection of a test specimen from the side wall and where guarantee of mechanical properties is required.

③Mechanical property determinations are not required for this temper.

Straight Talk—Many a designer with one eye on competition and the other on costs has found a practical answer in Alcoa Impacts. Oftentimes the solid technical suggestion of an Alcoa sales engineer or a slight revision in an engineering drawing by one of Alcoa's Impact experts has made a mighty sales advantage. This kind of help is ready and waiting at your local Alcoa sales office. You'll find it listed under "Aluminum" in your classified phone book. Better still, write for Alcoa's new design handbook, *Alcoa Impacts:* 32 pages. ALUMINUM COMPANY OF AMERICA. 1994-H Alcoa Building, Pittsburgh 19, Pa.

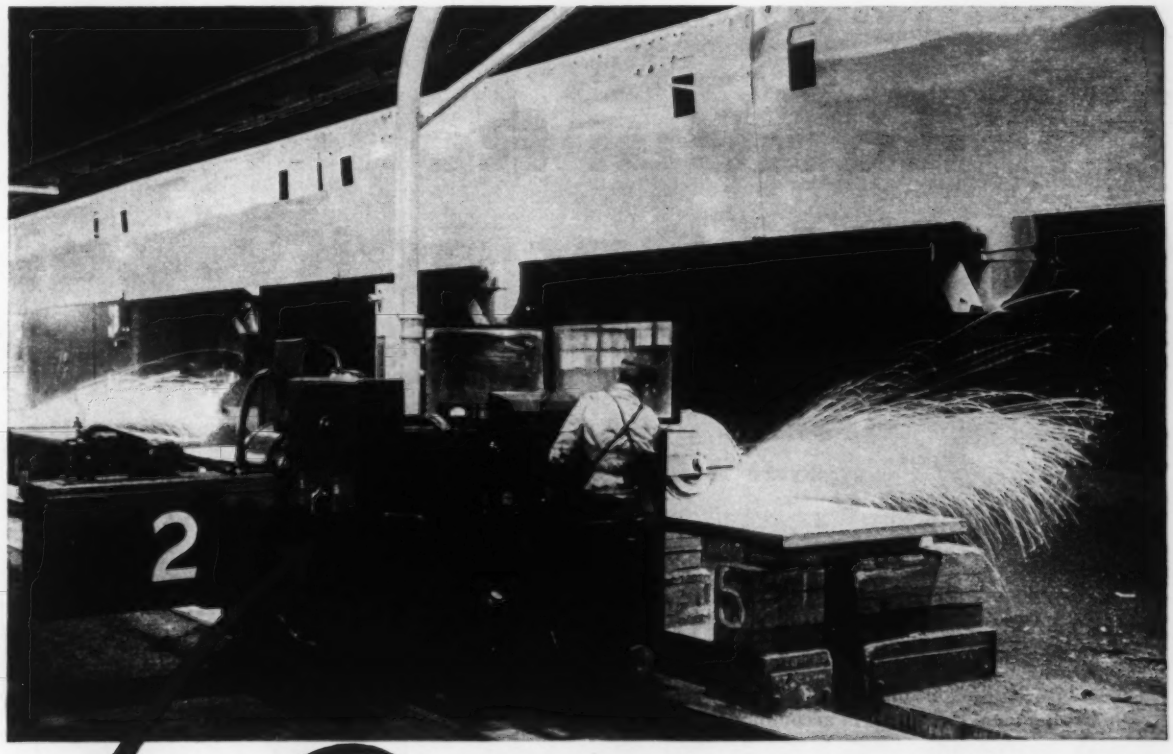
Your Guide to the Best in Aluminum Value

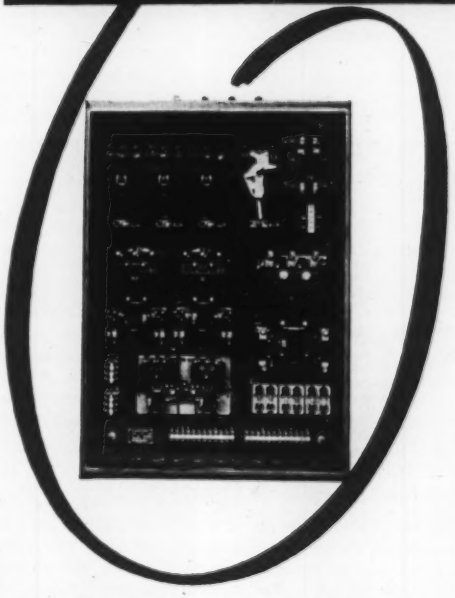
ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA
IMPACT EXTRUSIONS

one eye on competition and the other on costs

advertisement

Litho in U.S.A.





Clark Type "CY" Control Panel mounted on each machine contains a size 0 reversing, two size 2 and one size 3 Type "CY" motor starters.

CLARK Type "CY" CONTROLS

help Mid-West Slab Grinders triple output at Crucible Steel!

Ten track mounted billet grinders built by the Allied Machine and Engineering Co., a subsidiary of Mid-West Abrasive Company, are setting new performance standards at Crucible Steel's Midland, Pa. mill. Replacing manually operated and unwieldy swing grinders, these machines do the job better, faster and safer with electrically-controlled hydraulic positioning.

Accurate and complete control of stroke, wheel position, rotation and pressure results in smaller metal loss, less wear on grinding wheels and better finish. Clark Controls provide the accuracy and dependability these machines require, and prove again that Clark Type "CY" starters have the extra stamina required for heavy-duty mill-type service.

The **CLARK** **CONTROLLER** *Company*

Engineered Electrical Control

1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

—ITEM 528—

For More Information Circle Item Number on Yellow Card—page 19

Cylindrical Rollers for High Capacity...

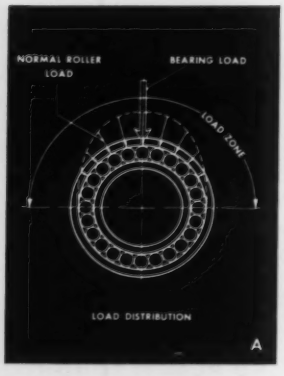
How the rollers distribute the load... effect of local deflection within rollers under load... how roller quality control increases bearing life

The principle of overcoming sliding friction with rollers was known even to the ancient Egyptian pyramid builders, but it is a far cry from their crude logs to precision-ground rollers. Today engineers have a wide choice of bearing designs, and selection is usually gaged by the fundamental yardsticks of accommodation, load-carrying capacity and cost. In many applications, properly designed plain bearings provide operating advantages. Ball bearings are ideal for other applications. But where heavy loads must be sustained in a relatively small bearing annulus, the only practical, commercially-available support is a set of hardened rollers operating in planetary fashion around a hardened inner race and housed in a hardened outer race . . . in other words, a *cylindrical roller bearing.*

Obviously, the design and quality of the *rollers* play a large part in the performance of the bearing. Here, briefly, are some of the vital factors which must be taken into consideration:

1. DISTRIBUTION OF LOAD WITHIN THE BEARING

Every roller in a rotating bearing is subjected to periods of load while in the "load zone," and periods of no load while outside the "load zone." Within this zone, the roller moves from a position of light load to a position on the line of action of the bearing load. Here the normal roller load is a maximum, and the roller in this position is the heaviest-loaded roller in the bearing. Moving beyond this point, the load diminishes to zero at the extremity of the "load zone," as shown in Diagram A at the left.

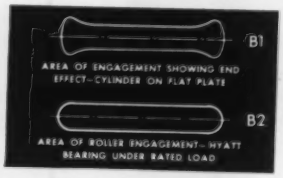


The theoretically perfect "load zone" extends from $-90°$ to $+90°$ measured from the line of action of the bearing load, for a total of 180°. But this is neither practical nor necessarily desirable, since it would require a bearing of zero internal clearance. If a bearing has internal clearance, then it has no "load zone" when under no load; only after load is applied does the heaviest-loaded roller deflect and permit its associates to share the load.

Under normal loadings, the actual "load zone" may range from 90° to 120°, depending on the load and mounted internal clearance. This distributes the load in the bearing so that the load on the heaviest-loaded roller can be approximated by 5/N times the bearing load, where N is the number of rollers.

2. DISTRIBUTION OF LOAD WITHIN ROLLER'S AREA OF CONTACT

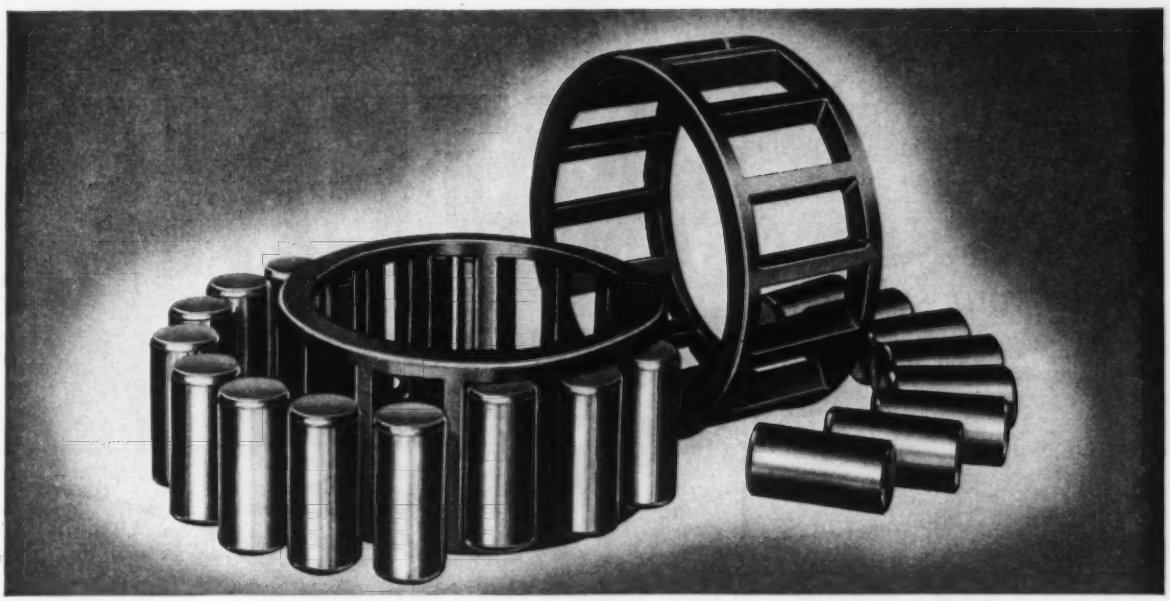
As load is applied to a cylinder between flat plates, the cylinder deflects locally in the region of engagement. The plate also deflects locally, so the original line of engagement under no load is broadened to become a "dog-boned" area (Diagram B1) under load. This broadening of the line of contact is analogous to the spread of the "load zone" from the heaviest-loaded roller to adjoining rollers, as previously described.


B1
AREA OF ENGAGEMENT SHOWING END EFFECT—CYLINDER ON FLAT PLATE
B2
AREA OF ROLLER ENGAGEMENT—HYATT BEARING UNDER RATED LOAD

One other effect is prominent here: deflected cylinders of finite length must gather in metal at their ends in *two planes*, instead of one, as is the case in the center of the roller. *This end-loading effect can seriously reduce the life of a cylindrical roller bearing.* All HYATT Roller Bearings have rollers of either generous corner radii or blended chamfers to reduce end effect. All HYATT Hy-Load Bearings, in addition to generous corner radii on the rollers, have a roller crowning extending a sufficient distance in from the ends to allow the area of contact to "fade out" evenly at the roller ends under normal loads, as illustrated in Diagram B2 above.

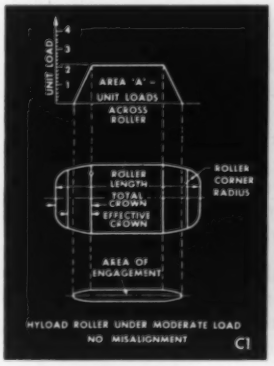
3. DISTRIBUTION OF LOAD ACROSS THE ROLLER

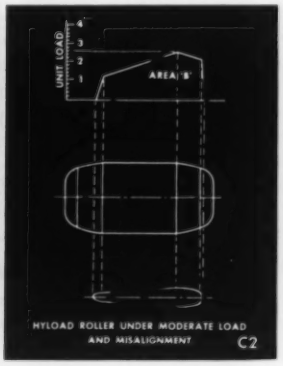
The unit load on any roller is distributed axially in a uniform manner except at the ends where crowning has been provided. Diagram C1 shows how the unit load drops off to zero at the



ends of the area of contact. The summation of unit loads represented by area "A" is the total roller load.

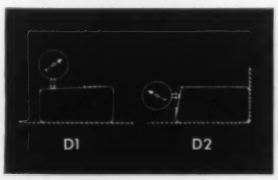
This same load applied under conditions of misalignment must result in an area "B" equal to area "A"; but it is apparent that the maximum unit load is considerably greater under such conditions and that the bearing will have a shorter life than one operating with little or no misalignment. Now observe the high unit load represented by area "C," resulting from the same total load applied to an *uncrowned* roller. This aptly demonstrates the value of crowning under conditions of misalignment. Moreover, the value of proper alignment is equally apparent (Diagram C2).



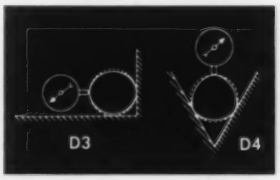


4. EFFECT OF ROLLER QUALITY ON BEARING PERFORMANCE

Quality of manufacture, particularly that of the rollers, has a great deal to do with the performance of a cylindrical roller bearing. For example:



1. A roller with excessive *taper* tends to uneven load distribution and abnormal temperature rise (D1).
2. A roller with excessive *end square* tends to noisy bearing performance (D2).
3. A roller with excessive *two-point out-of-round* tends to poor segregation and poor bearing life (D3).
4. A roller with excessive *three-point out-of-round* tends to noisy bearing operation (D4).
5. A roller with *poor finish* tends to wear on all operating surfaces and noisy operation.



6. A bearing with excessive *roller-to-roller diameter variation* tends to poor bearing life.
7. A bearing with excessive *roller-to-roller length variation* tends to poor thrust capacity and abnormal temperature rise.

All of these factors are scrupulously controlled by the most modern precision equipment to insure maximum performance and life for every HYATT Roller Bearing. HYATT has pioneered many advancements in the control of roller quality and is constantly seeking new ways to carry the complex loads of modern industry even more efficiently.

YOU WILL FIND MORE DETAILS in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type of cylindrical roller bearings best suited to your design requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors, Harrison, N. J.

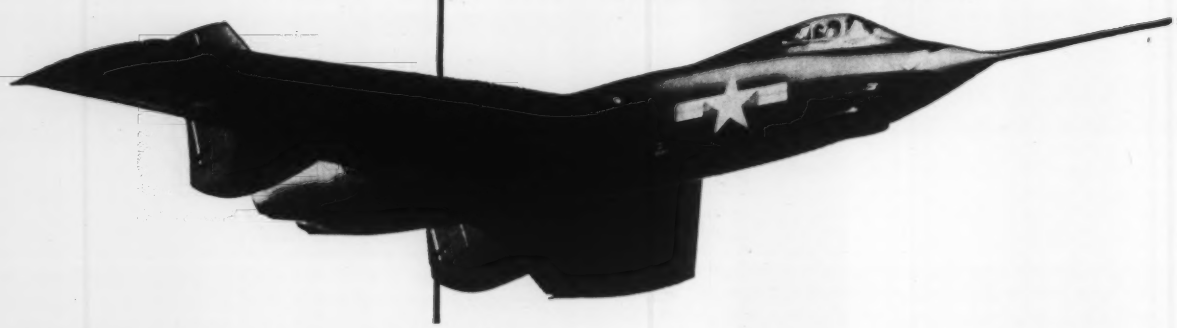
GM GENERAL MOTORS

HYATT ROLLER BEARINGS

For your selection

ALTEMP

HIGH TEMPERATURE SUPER ALLOY STEELS



ALTEMP A-286 . . . an austenitic iron-nickel-chromium alloy made heat-treatable by the addition of titanium. Designed to maintain high strength and corrosion-resistance up to the 1350 F range, and to afford satisfactory scale resistance up to 1800 F.

A-286 was developed in the A-L Research Laboratory in Watervliet, N.Y., in the 1949-51 period. Among the high-strength, heat-resisting alloys, it has exceptionally low strategic alloy content, improved hot-working and machining qualities, and good center ductility in large sections. Currently used in jet engines and superchargers for such applications as turbine wheels and blades, frames, casings, afterburner parts, bolting, etc.

This alloy is readily produced in large quantities without the need of special steel-making equipment. It is available in the form of billets, bars, forgings, sheet, strip, tubing and hot-extruded shapes.

ALTEMP S-816 . . . a chromium-nickel-cobalt base alloy, strengthened by additions of molybdenum and tungsten, and with a columbium-carbon ratio of ten to one to insure its structural stability. Designed for high strength and corrosion-resistance service in the 1200-1500 F range, and at higher temperatures under lower stress conditions. Developed in the A-L Research Laboratory at Watervliet, N.Y. in the years of 1940-43, and engine-tested and proved for periods of over 30,000 hours.

S-816 is used currently for turbine blades in two of the production jet engines, also in a number of experimental aircraft and commercial gas turbines. Except for seamless drawn tubing, it is available in practically all forms and shapes in which stainless steels are processed, including hot extrusions.

ALTEMP S-590 was designed for service in the range of 1100-1400 F temperatures where high strength and corrosion resistance are required, and where cost is also a factor. Unlike S-816, which is practically a non-ferrous alloy, S-590 has a chromium-nickel-cobalt-iron base. However, it employs the same molybdenum and tungsten additives, and the same columbium-carbon ratio.

S-590 was developed at the Watervliet Laboratory and field-proved during the same years as S-816. It is available in the same shapes and forms, and is currently being used for turbine blades and wheels in experimental commercial gas turbines.

OTHER GRADES . . . among the many other Super Alloys made by Allegheny Ludlum are V-36, M-252, 19-9 DL, 19-9 DX and Waspaloy.

Do you have a high temperature problem? The services and experience of our Research Laboratories and Technical Staff are completely at your command. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

WSW 8310 B

WRITE FOR INFORMATION

Certified laboratory data on the properties of Allegheny Ludlum high temperature Super Alloy Steels are yours on request.

ADDRESS DEPT. MD-79

PIONEERING on the Horizons of Steel

Allegheny Ludlum

Stocks of AL Stainless Steels carried by all Ryerson warehouses

AL® LEADING PRODUCER HIGH-ALLOY STEELS

—ITEM 530—

For More Information Circle Item Number on Yellow Card—page 19

quality and quantity
— in a hurry!

Today, there's only one *best* way to order "O" Rings, and get true compression—molded quality, mass-produced, delivered in a hurry, in quantities to satisfy anyone's needs!

LINEAR, with an exclusive high-speed process, produces ROTO-MOLDED "O" Rings with precise tolerances, absolute uniformity, flash-free surface and pre-stretched grain structure—at prices that command consideration.

Regardless of the compound used, the ROTO-MOLDING process with its scientific cure control, produces "O" Rings of improved physicals.

LINEAR ROTO-MOLDED perfect circle "O" Rings are produced in a variety of standard sizes and materials, plus special types and sizes for specific applications.

Write or call Linear today for the facts!

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

—ITEM 531—

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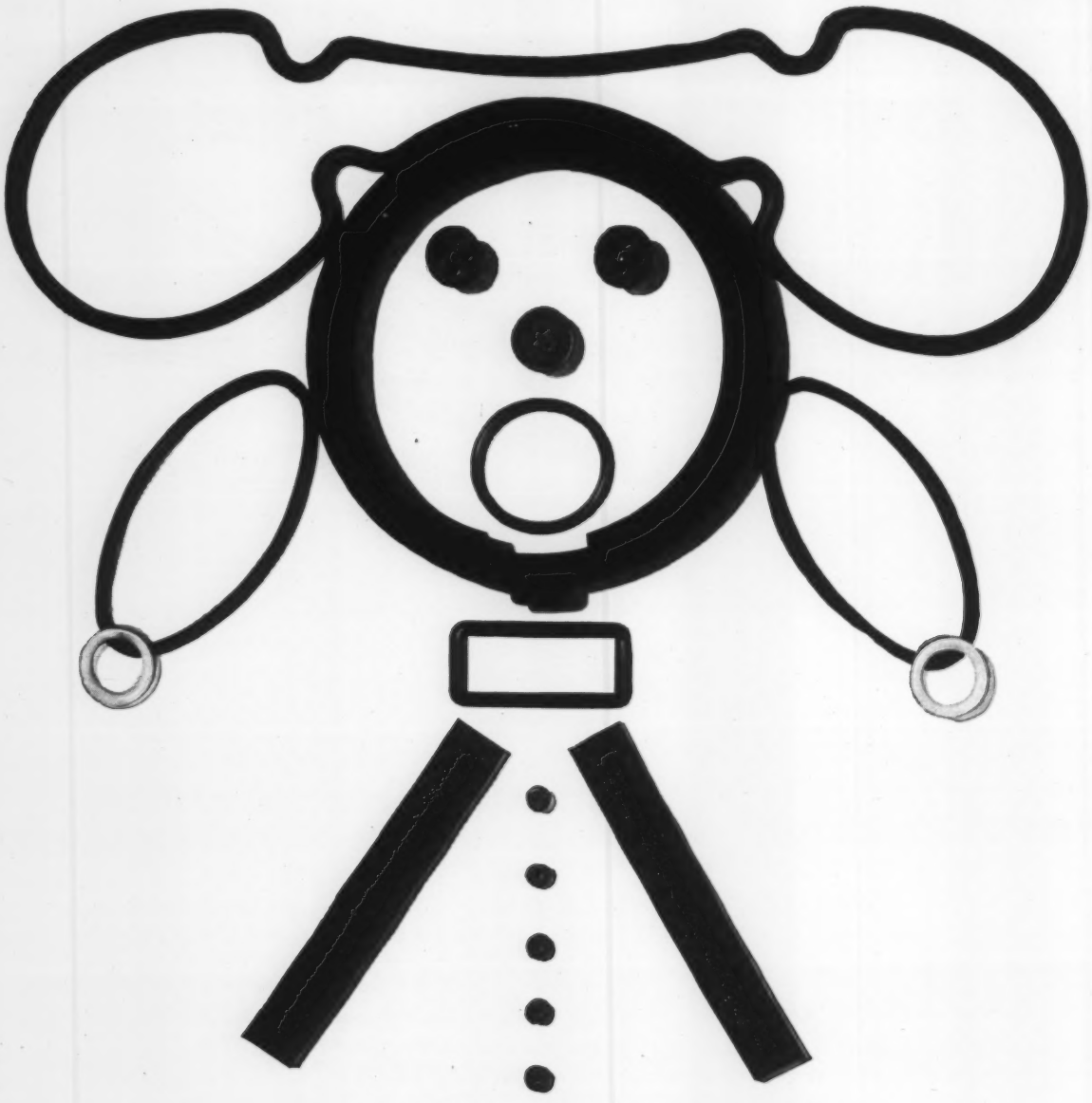


ROTH molds SILICONE
PARTS AND SPONGE

Why Silicone? • Extreme serviceable temperature range—from below −100°F. to +500°F. • High resistance to compression set—maximum of 20% from −25°F. to +325°F. • Exceptional resistance to oxidation—weathering, ozone and corona.

Why ROTH? • Top Production Know-How—33 years of experience serving hundreds of manufacturers—excellent engineering and production staff. • Better Service and Delivery—Roth can meet your deadlines. • Priced Competitively—proven by hundreds of satisfied clients.

If molded rubber is a problem—
let ROTH solve it.

ROTH
RUBBER COMPANY
1860 S. 54th Ave., Chicago 50, Ill.

—ITEM 532—
For More Information Circle Item Number on Yellow Card—page 19

INTRODUCING GRAPH-AIR®...

a tougher, more versatile graphitic tool steel that air-hardens at temperatures 200° to 300° lower with less distortion!

NO facilities for oil-quenching—or other relatively costly heat treating processes? Need a finer air-hardening tool steel? Then specify *Graph-Air,*® newest steel resulting from the Timken Company's pioneering in fine alloy steels. Latest addition to our line of quality graphitic tool steels!

Graph-Air tool steel air-hardens at temperatures of 1450°F to 1550°F—200° to 300° lower than most other air-hardening tool steels. And because Graph-Air *is* air-hardened, there's less distortion, easier heat treating control, less decarburizing. As a result, Graph-Air can be made into *more intricate sections.* Graph-Air is a tough air-hardening steel, too—made to order for such demanding applications as blanking dies, or any tool steel part which must take hard abuse.

Besides all the advantages of air-hardening—economy, less drastic reactions to quenching, less tendency to scale—Graph-Air offers greater wear, machinability and stability. Like Graph-Mo, Graph-Air will outwear other tool steels, because of the uniform diamond-hard carbides in its structure. And Graph-Air machines 30% faster. The free graphite in its structure acts as a built-in lubricant. And Graph-Air stays *accurate longer,* is fully as stable as other Timken Company graphitic tool steels, which are the most stable tool steels made!

Growing out of the Timken Company metallurgists' long experience with fine steel making, Graph-Air—the *new* graphitic tool steel that can be air-hardened at *low* temperatures—will be available in both solid and hollow bar sizes. For more information, write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* STEEL

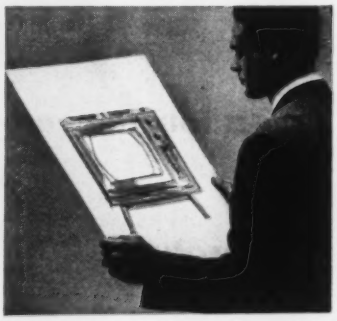
TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

MONSANTO

Competition for tomorrow's markets imposes a heavy responsibility on the men who design for industry. In their constant search for ways to improve products within definite cost boundaries, many of them are working closely with plastics engineers in the custom molding industry. These pages report on how the unique properties of plastics helped RCA designers create an important component for a color television set. It is more than likely that custom molders, who are devoting their lives to craftsmanship in plastics, can contribute to solving some of your problems.

How RCA designers engineered a color television mask in Lustrex styrene plastic



DESIGN OBJECTIVES. Model sketches for the new RCA Victor* color television set called for a mask opening which would frame the kinescope in established size and permit a maximum viewing angle. A leakage path of six inches was required between high voltage bearing metal surfaces and adjacent points on the instrument subject to spectator contact. The mask had to be capable of supporting the front end of the kine in the cabinet. It had to combine utility with attractive appearance, in a color that would not detract from the color kine picture.

MATERIAL SPECIFICATIONS. After studying various materials RCA designers and engineers decided that a rigid mask molded of styrene plastic would best meet objectives. While a thin covering of insulation would have met specifications electronically, it did not offer the mechanical strength to support the kinescope properly. RCA experience with high-impact styrene masks for monochrome receivers had demonstrated their ability to support and locate the kine in position. At the same time they protected users from direct contact with it. By custom molding the mask in one piece, the part could be supplied ready for assembly and painting.

PRODUCTION ENGINEERING. RCA commissioned Amos Molded Plastics Company, Edinburg, Indiana, to supply the component. Tool design in the Amos plant was supervised by Dale E. Hickey, Chief Engineer. Monsanto Lustrex Hi-Test 88, a rubber-modified high-impact styrene plastic, was specified. Delivery of the kinescope masks began three weeks after the initial order was placed. Every design requirement was met satisfactorily by custom molding the mask of Lustrex Hi-Test 88.

THE FINISHED SET. The smartly designed cabinets of the new RCA Victor* color television set are exerting great consumer appeal in showrooms across the country. Smooth finish of the fluted plastic mask harmonizes richly with the high-styling of the complete unit.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. These 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Application Dept., Springfield 2, Mass.

Investigate the completely balanced line of Monsanto styrene compounds for particular applications, sold under the trade name . . .

LUSTREX
Styrene Plastic

*RCA trademark

MONSANTO

Design Features Enable Redmond to Put More Horsepower into Smaller Motors

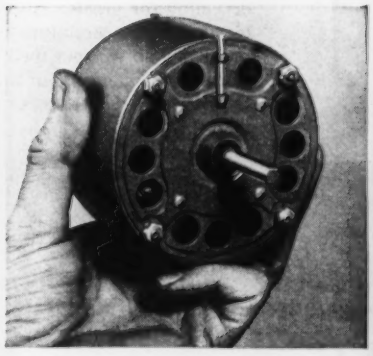
Two design features that are available for the first time in a small-diameter motor have made the development of the new Redmond AL-4 MicroMotor possible. These new features result in a motor that is smaller and lighter in weight but offers increased horsepower.

The patented Redmond Tri-Flux design, which is illustrated and described in the box below, greatly increases the efficiency and starting and running torques of the new AL-4 over conventional motors of this size.

The Redmond Uni-Cast construction allows the precision manufacturing that results in a motor that is smooth-running and quiet in operation and that can be depended on to give years of service-free performance. With Uni-Cast construction the stator core frame is precision die cast in one piece under extremely high pressure, which prevents the shifting of laminations during manufacturing, handling, and motor use. By machining both stator core registers simultaneously, the registers are held concentric with each other and to the bore at extremely close tolerances. The end frames which are then set into these machined registers provide exact bearing alignment and a uniform air gap. This manufacturing technique and the elimination of magnetic wedges assure long life and whisper-quiet operation.

Because of the special die-cast material used in the construction, this motor is very lightweight. Casting the stator core frame in one piece makes the AL-4 rugged and durable.

Motor shorts and grounds are virtually eliminated through the use of thermo-setting phenolic end turn insulators. Oil wicks are made of spun nylon which not only increases capacity and retention, but gives more uniform oil distribution.



New Redmond AL-4 Tri-Flux Motor Is Designed for More Horsepower in an Economical, Quality Package

The design of the AL-4 makes it ideal for heating, ventilating, air conditioning or refrigeration equipment, for appliance applications, and for business and vending machines, pumps, tape recorders, and the dozens of other motor applications where economy is a factor and yet high quality is needed. The basic AL-4 is a 4-pole motor, 1550 r.p.m., 115 volts, 60 cycles. It is also available in odd voltages and frequencies, or in either open ventilated or totally enclosed construction. It develops 1/250th to 1/15th horsepower. The shaft is $\frac{1}{16}$ inches in diameter. There are 14 lead outlets. These motors are built of Underwriters' Laboratories approved materials. Although designed for a wide variety of applications, the AL-4 can be tailor-made for specific requirements.

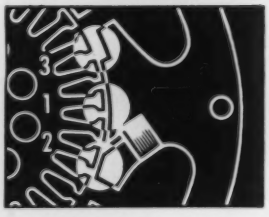
Descriptive Brochure Available

For the complete story on the new AL-4 motor – dimensions, performance, operational data, and suggested applications—write the Redmond Co., Owosso, Michigan for the "AL-4 Bulletin."

How Tri-Flux Design Improves Performance by Adding a 3rd Area of Magnetic Flux

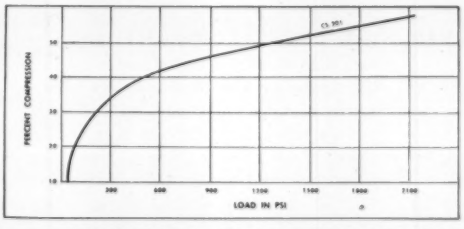
The salient pole single phase induction motor has only one flux path—indicated by the white circle—between the field and the rotor. The motor is not self-starting—for commercial value a starting mechanism must be added.

The second white circle indicates the flux path added by wrapping a shading coil around the trailing pole tip. Power and uni-directional action are increased in this shaded pole induction motor, and it is now self-starting. This motor is now practical at low cost, and is used for applications requiring limited starting torque.



Note that a third flux path has been added at the leading pole tip. This was accomplished by Redmond's Tri-Flux design, whereby a "reluctance notch," which can be seen in the third white circle, is put in the leading pole tip. Efficiency and starting and running torques are greatly increased. New applications are opened to these improved, low-cost motors.

Accopac® fiber gasket seals tightly under low flange loads

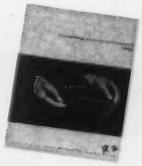


HIGH COMPRESSIBILITY of Accopac CS-301 is shown by load-compression curve. With light metal flanges, this compressibility allows gaskets to conform to surface irregularities and form a tight seal without distorting flange.

Armstrong CS-301 Accopac is an improved beater-saturated gasket material that becomes impervious to both liquids and gases at flange pressures as low as 800 psi. This fiber-cork-rubber composition does an excellent sealing job in light-weight metal assemblies.

CS-301 Accopac is highly compressible and resilient. It conforms to normal surface irregularities on stamped flanges and on rough-finished cast flanges.

This unusual fiber material will not shrink or dry out; its special latex binder is non-volatile and non-extractable. CS-301 maintains a tight seal even in alternately wet and dry applications.



For more information and copy of "Armstrong Gasket Materials," write Armstrong Cork Company, 7007 Dean Street, Lancaster, Pennsylvania.

Armstrong ACCOPAC

DIAMOND ROLLER CHAINS

YES, that's the DIAMOND trade mark!

THE SIGN OF UNIFORM QUALITY

Ever since Diamond Chain Company was established over 65 years ago—all effort has been focused on *one* product—Roller Chain.

The high *uniform* quality, the extreme smoothness of operation, reserve strength and long-life dependability of Diamond Roller Chains now mean more than ever before—good reason for their constantly increasing use on the finest machines and equipment made by America's leading manufacturers.

Because of the ever-widening field of application, you, too, will find it helpful to get practical recommendations from our experienced engineering staff.

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DIAMOND **ROLLER CHAINS**

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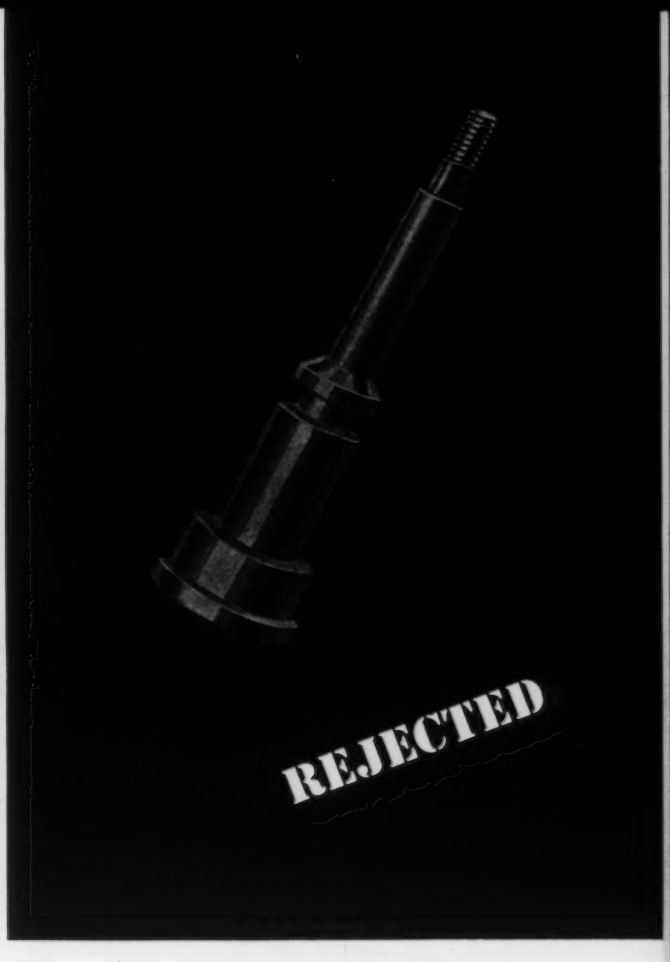
For More Information Circle Item Number on Yellow Card—page 19
Facing Page—ITEM 538→



THE DIFFERENCE... *Carpenter* stainless machinability

Here are two reasons why the machining of these seating valves presented a problem in this shop: Tolerances of ± .0005" must be held because they contribute greatly to the operation and service life of the part. Further, the length of the part makes thread cutting on the small end a ticklish operation.

Rejects were running high and costs were excessive when the company was using an ordinary Type 303 Stainless.

Where was the answer? The trouble had to be in the stock . . . yet originally it was thought that the stainless being used would fill the bill. With the trouble at hand, the job obviously called for something better in machinability.

Following this reasoning, the company started to ask questions about easier-machining stainless steels. The answers pointed to Carpenter—originators of the world's first free-machining stainless.

Carpenter Stainless No. 8 (Type 303) was assigned to the job. Now close tolerances are held consistently . . . rejects are considerably reduced . . . and in all other ways the job is a lot easier.

Why be satisfied with "average" stainless steel performance when Carpenter is ready and able to help you? For immediate delivery of the finest Free-Machining Stainless Steels available today, put in a call to your nearest Carpenter Mill-Branch Warehouse or Office.

Specify Carpenter . . . the one Stainless Job-Proved to give you:

easier machining
fewer rejects
smoother finishes
lower production costs

Carpenter STEEL

Free-Machining Stainless Steels

IMMEDIATE DELIVERY from local warehouse stocks—THE CARPENTER STEEL CO., 120 W. Bern St., Reading, Pa.
Export Address: Port Washington, N. Y.—"CARSTEELCO"

AN ALUMINUM COST

This cost savings story points the way to big economies for you!

PART I

CAMERA TRIPOD PART Converted from steel to aluminum. Cost savings per 1,000 parts . . . 38.4%

. . . based on material and production costs per part of $1.90 for steel and $1.17 for aluminum. Figures given do not include the cost necessary for plating had steel been specified. Because of aluminum's attractive finish and resistance to rust, anodizing was the only finishing operation required. This part is one of a number of different aluminum parts used in the camera tripod.

PART IV

BUSHING — Converted from brass to aluminum. Cost savings per 1,000 parts . . . 53%

Lower raw material costs were entirely responsible for these savings. Only 22 pounds of aluminum at $.56 a pound were required for 10,000 parts. Brass, however, required 67 pounds for the same job. At $.42 a pound, the total cost for brass was $28.14, less $4.58 for scrap recovery. Aluminum's total cost was $12.66 for every 10,000 parts produced.

PART V

WINDSHIELD WIPER KNOB INSERT — Converted from brass to aluminum. Cost savings per 1,000 parts . . . 24.8%

Because of the savings offered by aluminum, engineers tested it along with other materials for this particular application. They found aluminum would not only provide sufficient strength but would also take a slightly better knurl.

SEE "THE KAISER ALUMINUM HOUR" Alternate Tuesdays, NBC Network. Consult your local TV listing.

STORY IN FIVE PARTS

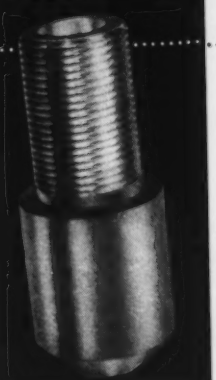
PART II

NOZZLE — Converted from brass to aluminum. Cost savings per 1,000 parts. . 24.9%

Set up time and labor costs were equal between brass and aluminum. But brass required 32.4 pounds for 1,000 nozzles while aluminum required only 10.66 pounds. The difference in material cost, therefore, was $7.86 or 24.9% saved per 1,000 parts in lots of 10,000.

PART III

INSERT — Converted from steel to aluminum. Cost savings per 1,000 parts. . . 35%



Cost savings on this part were due to lower machine time and not raw material costs. Aluminum's faster machinability permitted a two-third reduction in machine time per 1,000 parts.

HOW YOU SAVE WITH KAISER ALUMINUM

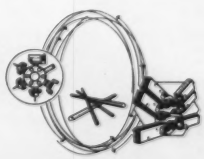
The five companies whose parts are shown here — like parts buyers all over the country — have discovered that Kaiser Aluminum stock can give them big savings and better quality.

You get *three times* as many parts from a pound of lightweight Kaiser Aluminum stock as from a pound of brass or steel. Thus, each part can cost far less.

And you often get *better* parts because aluminum provides a unique combination of useful advantages, including lightness with strength, handsome finish, corrosion resistance, good heat and electrical conductivity.

For more information or assistance, look for our local number in the classified telephone directory under the heading "Aluminum." Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

Kaiser Aluminum



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Technical Editor,
Kaiser Aluminum & Chemical Sales, Inc.,
919 N. Michigan Ave.,
Chicago 11, Illinois

Please send, without obligation, my copy of "Machining Kaiser Aluminum" which I understand is a hard-cover, library volume containing information of value to me when designing with aluminum.

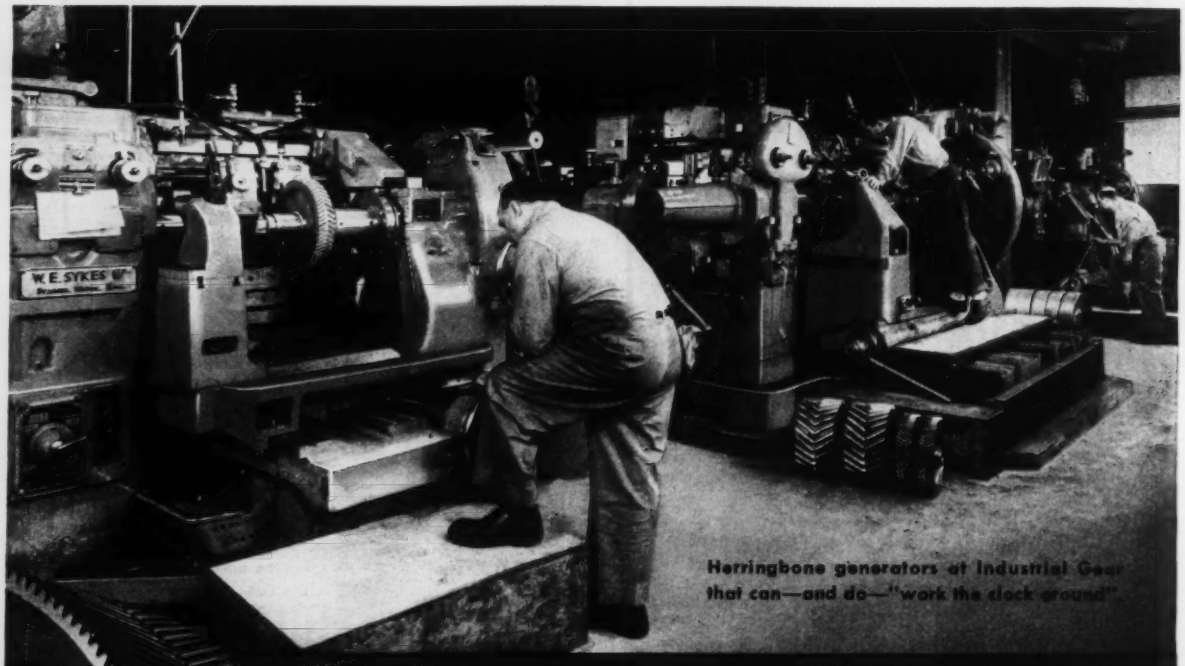
Name _____ Position _____

Company _____

Address _____

City _____ State _____

—ITEM 539—



Herringbone generators at Industrial Gear that can—and do—"work the clock around"

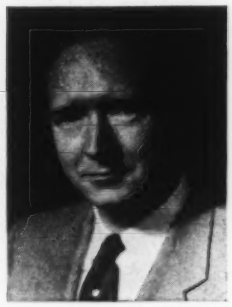
Greater than ever . . . HERRINGBONE PRODUCTION CAPACITY!

AGMA

INDUSTRIAL GEARS

SIER-BATH GEARS

—ITEM 540—
For More Information Circle Item Number on Yellow Card—page 19



MACHINE DESIGN
JULY 26, 1956

A Source of Manpower Waste

IT HAS been said that science knows no frontiers. Knowledge of the basic principles of engineering and technology cannot for long be retained for the exclusive use of the nation—or the manufacturer—that first discovers them. Scientists and engineers working on the same problems will in the long run make the same discoveries.

Most engineers in true professional spirit are striving to share their discoveries and experience with others. The programs at engineering society meetings are becoming larger every year and there are now more engineering journals publishing more articles than ever before.

Yet a significant number—because of classification policies, or fear of relinquishing some advantage to a competitor—are not permitted to divulge anything of their work. Of course, there is an area of trade secrets which must be respected—just as there is an area of national security. But too often these legitimate safeguards are employed to prevent disclosure of basic findings that could benefit industry, the nation, and the world.

Again, those with authority to say yes or no on publication of information often lack the background to distinguish principles and basic facts from specific data that properly should be withheld from a potential enemy or a competitor. (During World War II, a censor once forbade us to publish the fact that 2.1 pounds of oxygen are needed to burn a pound of ethyl alcohol.)

In consequence of the increasing use of secrecy to cloak engineering activities, industrial espionage is reaching new proportions. So large does it loom in some quarters that there is danger of the usual channels of communication being bypassed. Preoccupation with spying on others could mean neglect of already available information in periodicals and books that flows constantly into engineering departments and libraries at little or no cost.

Precious engineering manpower is being wasted because of secrecy and espionage. Much engineering effort is being duplicated because communication is hampered by security and other restrictions. And the cost of obtaining information by espionage must be astronomical—both in dollars and in manpower.

Engineers can help reduce the waste in two ways. Being in position to know whether or not certain engineering information will jeopardize security or competitive advantage, they can help free up communication by pointing out what can safely be published. And they can see to it that published literature is combed for information and ideas.

It is worth remembering that the leaders in the field got there by being always a few jumps ahead of their competitors—not by harboring secrets or stealing the ideas of others.

Colin Carmichael

EDITOR

10 Library KEYS for Engineers

By Edwin W. Still, *Utica, New York*

AN EXPERIENCED designer is certainly more valuable than one who has just begun. Yet any design engineer, young or old, who has the necessary keys can find stored away in libraries more experience than one man alone could acquire in a lifetime.

The purpose of this article is to provide these keys as they are represented by library facilities and services. The keys should not be confused with engineering subject matter itself. They are, rather, the means by which the engineer may find the particular material his problem requires. There are two kinds of keys — active and passive. They represent the services and the facilities a library offers. Both kinds open doors of opportunity.

1—Card Catalogs

The first key is the card catalog. Arranged alphabetically, it has one or more cards for each book or other item indexed in the library.

The card catalog in most libraries is the type known as a dictionary catalog which means it is three types combined. An author catalog, a title catalog, and a subject catalog are gathered into one alphabetical arrangement. An engineer may search for a desired book by looking under whichever of the three he happens to know.

The cards themselves provide useful information beyond the call number by which books may be requested or found on the shelves. Some libraries type their own cards but most now purchase cards printed by the H. W. Wilson Co. or the Library of Congress and type in the headings and call numbers they prefer. More than 6000 libraries in the United States subscribe to the Library of Congress service of printed cards.

A typical Library of Congress Card is shown in Fig. 1. Copies of the same card, but with the different headings or "entries", are placed in the dictionary catalog at the proper alphabetical locations. Thus a book may be found if only one of the entries is known.

The cards in Fig. 2 illustrate the varied information which may be included. Some may be particularly informative, such as the one for Freburg. It shows that in two books there is a whole course available, with text, diagrams, problems, answers to the problems, and a bibliography for further reading.

2—Classification Systems

Basic to the card catalog is the master-key for the entire library. This is the classification system by which the diverse subject matter in a library is organized logically and systematically. Two systems predominate: Decimal Classification and Library of Congress Classification.

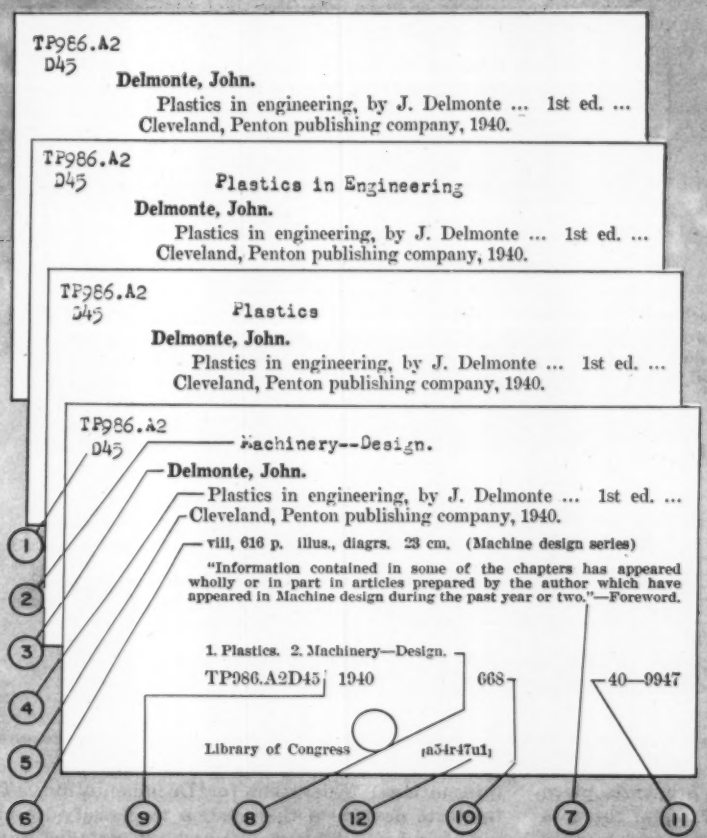
Decimal Classification was originated by Melvil Dewey in 1873. The first edition of Dewey classifications had 42 pages and was dated 1876. It has been extended and perfected by a great many specialists until the fourteenth edition of 1942 was a volume of 1927 pages. It is now used in most public libraries and many school and college libraries in the U. S. and is also followed in many foreign countries.

As Fig. 3 illustrates, Decimal Classification provides a step-by-step development from very general Classes of all knowledge to very specific subjects. The ten Classes are the base of the whole system. Each step downward from the general Class to the specific subject is indicated by a movement of one place to the right in the decimal num-

MACHINE DESIGN
28(15):58-65

10 Systems and services which expedite the search for technical information

Fig. 1—Copies of this typical Library of Congress catalog card are filed alphabetically by author name, book title and two subjects. The second subject copy shows the elements of a complete card.



1. **Call Number.** This is the number by which this particular book is classified.

The Call Number has two parts: the classification number, TP986.A2 for this book, and the book or author number, D45. The same classification number is applied to all books in the same subject classification, so all of them will be found together on the shelves.

Sometimes a library will have a separate card index known as the Shelf List or Classified Catalog in which the cards are all arranged by these call numbers. If the classification number desired is known the engineer may look in the Shelf List and read the cards for all the books the library has on that subject.

A number of classification systems are in use but most libraries follow either the Library of Congress system or Decimal Classification.

2. **Entry.** This is the descriptive heading under which the book is entered in the catalog. Books are almost always entered under author and title, and usually under one or more subjects. It is advisable to look at the author card first, if his name is known, because sometimes the other cards do not contain as much information.

3. **Author.** The author's name is inverted, as in most alphabetical directories. The year of the author's birth, or the years of his birth and death, are often given immediately following his name.

4. **Title.** Along with the book title itself, this item includes the edition, the names of all authors on the title page, and an indication that the author is actually editor if it is a collected volume of papers by a number of authors. Titles in foreign languages are given in the language used on the title page.

5. **Imprint.** The place of publication, the publisher, and the year of publication are given by this item.

6. **Collation.** A number of facts about the physical make-up of the book are given by this item. The collation on this card indicates that the book has eight pages numbered with Roman numerals (usually the preface, etc.) plus 616 pages with Arabic numerals. It is illustrated, contains diagrams, and is 23 centimeters in height. It is one of the books in a Machine Design series.

7. **Notes.** Under this item additional information is recorded which will often help the engineer decide the probable usefulness of the volume for him. On the card shown the Foreword of the book is quoted to show that some of the information appeared earlier in articles in MACHINE DESIGN magazine.

8. **Tracing.** Indications on one card which show the other entries under which this same book is indexed are called the *tracing*. This information may be very valuable for it tells the engineer the subject headings under which he may find a number of other books dealing with the same subject.

9. **Library of Congress Call Number.** This is the Call Number according to the Library of Congress classification system.

10. **Decimal Classification Number.** This is the classification number, 668 for this book, according to the Decimal Classification system. If the library is using this system it will add a book number such as D45 and type the two in the upper left corner of the card to become the Call Number. The printed Library of Congress card tells the engineer the classification by both systems.

11. **Library of Congress Order Number.** This is of importance primarily to the librarian for it is the number by which he may order additional copies of the same card.

12. **Copyright Code Number.** This is also for the librarian and refers to the copyright of the book.

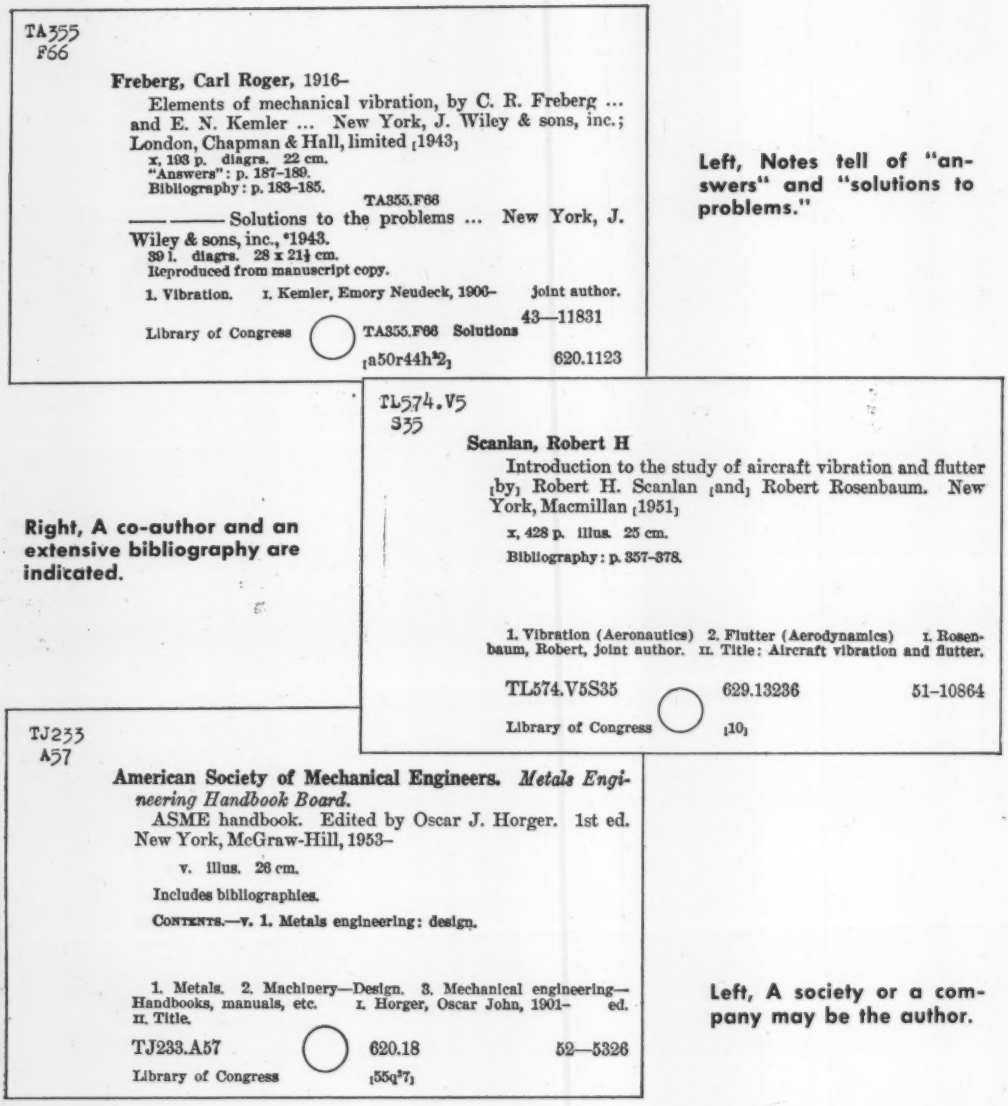

TA355
F66
Freberg, Carl Roger, 1916–
Elements of mechanical vibration, by C. R. Freberg ... and E. N. Kemler ... New York, J. Wiley & sons, inc.; London, Chapman & Hall, limited [1943]
x, 193 p. diagrs. 22 cm.
"Answers": p. 187–189.
Bibliography: p. 183–185.
TA355.F66
——— ——— Solutions to the problems ... New York, J. Wiley & sons, inc., °1943.
39 l. diagrs. 28 x 21½ cm.
Reproduced from manuscript copy.
1. Vibration. I. Kemler, Emory Neudeck, 1906– joint author.
Library of Congress TA355.F66 Solutions 43—11831
[a50r44h32] 620.1123
Left, Notes tell of "answers" and "solutions to problems."
TL574.V5
S35
Scanlan, Robert H
Introduction to the study of aircraft vibration and flutter [by] Robert H. Scanlan [and] Robert Rosenbaum. New York, Macmillan [1951]
x, 428 p. illus. 25 cm.
Bibliography: p. 357–378.
1. Vibration (Aeronautics) 2. Flutter (Aerodynamics) I. Rosenbaum, Robert, joint author. II. Title: Aircraft vibration and flutter.
TL574.V5S35 629.13236 51–10864
Library of Congress [10]
Right, A co-author and an extensive bibliography are indicated.
TJ233
A57
American Society of Mechanical Engineers. Metals Engineering Handbook Board.
ASME handbook. Edited by Oscar J. Horger. 1st ed. New York, McGraw-Hill, 1953–
v. illus. 26 cm.
Includes bibliographies.
CONTENTS.—v. 1. Metals engineering: design.
1. Metals. 2. Machinery—Design. 3. Mechanical engineering—Handbooks, manuals, etc. I. Horger, Oscar John, 1901– ed. II. Title.
TJ233.A57 620.18 52—5326
Library of Congress [55q37]
Left, A society or a company may be the author.

Fig. 2—Selected Library of Congress catalog cards illustrate special cases and entries in addition to regular information.

ber. The system begins with the hundreds place being used for the Class. Theoretically, there is no limit to the fineness of classification which could be obtained by adding digits successively to the right. Expansion within the system is also possible. New groups of subjects can be added as subsections of another group which they logically equal in number and rank.

Universal Decimal Classification, often known as Brussels Classification, is an expansion of the Dewey system. First published in 1899, it was established at Brussels, Belgium, by the Institute International de Bibliographie, now known as the International Federation for Documentation. The Institute developed this system to classify its universal subject bibliography which included cards for periodical articles as well as books in all languages. Universal classification provides more adequately for the fields of science by including more minute subdivisions than Dewey contained.

Not many libraries use the Universal Decimal Classification, but a few very important ones do. The Engineering Societies Library in New York is one.

Library of Congress Classification, developed over the past fifty to sixty years, is somewhat

younger than the system begun by Dewey. It has a number of advantages, however, which have led to its adoption by many college and university libraries and by many specialized libraries. Among these are many company engineering libraries.

Two advantages such libraries find in the L. C. scheme are that its subdivisions are minute and its notation is elastic. It adapts particularly well to large libraries or to specialized libraries. In addition, its source is authoritative.

Fig. 4 illustrates subdivisions in Library of Congress Classification through the use of both letters and numbers. Capital letters, either singly or in combinations, indicate the large classes and the divisions within these classes. Within the divisions the subjects are noted by Arabic numerals arranged consecutively. The subjects may be thought of as belonging to various groups, like *Machine Design, Steam Engineering,* and such; but the numerals run consecutively within each division regardless of the group. The only gaps in the numbering are those left for expansion. Whole blocks of numbers may be assigned later to new subjects. Similarly, the letters I, K, O, W, X, and Y allow for the development of at least six more large classes.

The example in Table 1 shows how a particular subject, in this case TP986 Plastic materials, may be subdivided by the addition of decimal numbers or a decimal point followed by a letter and a number. A book on cellophane would be classified TP986.C4, and one on plastic eye protectors would be TP986.5.E9. To complete the call number for each of these books, another letter and number would be added to these classification numbers to indicate the author. Thus the book by John Delmonte, in Fig. 1, is classified TP986.A2 to indicate that it is a general work on plastic materials. Its complete Call Number is TP986.A2D45.

3—Indexes to Periodicals

A third key to the potential knowledge in the library storehouse is the indexes to periodicals.

In technology, as well as in science, developments come so rapidly today that much of the engi-

DEWEY DECIMAL CLASSIFICATION

Classes of Knowledge
000 General works
100 Philosophy
200 Religion
300 Social Sciences
400 Philology
500 Pure Science
600 Useful arts, applied science
700 Fine arts
800 Literature
900 History, biography

600 Useful arts, applied science—general works
610 Medicine
620 Engineering
630 Agriculture
660 Chemical technology
690 Building

620 Engineering—general works
621 Mechanical
622 Mining
629 Other branches
629.1 Aeronautics, aircraft
629.2 Motor vehicles, automobiles

621 Mechanical Engineering—general works
621.1 Steam Engineering
621.2 Hydraulic engines or motors
621.8 Millwork, Hoisting and conveying machinery
621.9 Machine tools

621.9 Machine tools—general works
621.91 Planing and milling machines
621.92 Grinding and filing, abrasives
621.93 Cutting and sawing
621.98 Bending, straightening and shaping

621.92 Grinding and filing, abrasives
621.922 Cylinder & surface grinding machines
621.923 Emery wheels

Fig. 3—An example in the Decimal classification system shows how the subject 621.923, emery wheels, is related to the classes of all knowledge.

LIBRARY OF CONGRESS CLASSIFICATION

A Polygraphy
B-BJ Philosophy
BL-BX Religion
C-D History (except American), Genealogy
E-F American history
G Geography, Anthropology
H,J Social, economic and political science
L Education
M Music (literature)
N Fine arts
P Language and literature
PZ Fiction and juvenile literature in English
Q Science
R Medicine
S Agriculture
T Technology
U Military science
V Naval science
Z Bibliography

T Technology—General
Engineering and Building Group
TA Engineering—General. Civil Engineering
TH Building. Fire Prevention and Extinction
Mechanical Group
TJ Mechanical Engineering
TK Electrical Engineering and Industries. Electronics. Atomic Power
TL Motor Vehicles. Cycles. Aeronautics
Chemical Group
TN Mining Engineering. Mineral Industries
Composite Group
TS Manufactures

TJ Mechanical Engineering
TJ 1 thru TJ173 General
TJ175 thru TJ220 Mechanical Movements. Gearing
TJ227 thru TJ266 Machine Design and Drawing
TJ751 thru TJ830 Misc. Motors and Engines
TJ840 thru TJ935 Hydraulic Machinery
TJ950 thru TJ1025 Pneumatic Machinery
TJ1425 thru TJ1475 Lifting and Pressing Machinery
TJ1501 thru TJ1560 Sewing Machines and Other Special Machinery

Machine Design and Drawing
TJ227 Drafting-room practice
TJ230 General
TJ235 Graphic statics applied to machinery
TJ250 Prime movers in general
TJ253 Testing
TJ266 Heat pumps

Fig. 4—An example of the Library of Congress classification system shows the use of letters and numbers and the relation of Machine Design and Drawing subjects to main classes.

neer's library searching has to be done in the scientific, technical, and trade periodicals. Keys to this literature are the indexes to periodicals and the abstract journals.

Two of many indexes published are the *Industrial Arts Index* and the *Engineering Index*. The two are similar in that both index articles on technical and scientific subjects. In other respects they are quite different and supplement each other in a number of ways.

Industrial Arts Index is published monthly by H. W. Wilson Co. and is sold to libraries on a service basis. It is cumulated at the end of two-month and four-month periods throughout the year, and an annual cumulation is issued at the year's end. Each cumulation, of course, simplifies the searching task. In it are indexed, by subject, the articles appearing in a selected list of engineering, trade, and business periodicals. Sometimes books and pamphlets are included. A typical monthly issue lists 285 periodicals as being indexed.

The subjects covered include the various branches of engineering, science, industry, business and finance, public administration, and management. Full references are given for the articles, which are listed only under subjects, but no annotations are included as in the *Engineering Index*.

A typical page of the *Industrial Arts Index*, Fig. 5, shows the large number of sub-headings into which a subject such as "Machinery" may be divided. This greatly eases the searching task. The engineer must be careful, however, to think of and check all the various subjects and forms of subjects which might list articles of interest to him. "Machine Design," for example, is not a subject heading, but general articles on machine design are listed under "Machinery," subheading "Design."

In addition to the kind of information indicated by the typical examples, the *Industrial Arts Index* often includes, especially in the annual volumes, other special subheadings. For example, in the 1954 volume under the subject "Radio Apparatus" there are the following subheadings and entries:

Bibliography

Abstracts and references. Published in monthly numbers of Wireless Engineer; reprinted in Institute of Radio Engineers Proceedings.

Directories

Directory of microwave equipment manufacturers. Tele-Tech 12:77 N'53

Directory of printed-circuit product manufacturers. Tele-Tech 12:81 D'53

Thus the engineer making a thorough search for information about radio apparatus has called to his attention a large source of abstracts and two directories of specialized manufacturers.

Table 1—Example of Library of Congress Classification System

TP986	Plastic materials	
.A1	Periodicals and societies	
.A2	General Works	
.A5 to .Z	Special plastics	
	Examples: .B3	Bakelite
	.C2	Casein
	.C4	Cellophane
	.C5	Celluloid
	.F5	Fiberloid
	.L8	Lucite
	.P5	Plexiglas
	.V5	Viscose
TP986.5	Articles made of plastic materials	
.A2	General	
.A5 to .Z	Special plastics	
	Example: .E9	Eye protectors

Table 2—Typical References in *Engineering Index*

STRENGTH OF MATERIALS
See also Elasticity; Hardness Testing; Materials Testing; Materials Testing Apparatus; Metalography; Metals Fatigue; Metals Testing; Paper Testing; Plasticity; Steel Testing; Stresses; Structural Design.

. .

Design Properties of Materials, R. L. STEDFELD. MACHINE DESIGN v25n10,11 Oct. 1953 p 138-48, Nov. p 161-70, v26n2 Feb. 1954 p 163-73; *see also* Engrs.' Digest v15n4 Apr. 1954 p 144-6. How properties data can be used more effectively for materials evaluation and selection. Oct. 1953: Properties and design. Nov: Strength in tension. Feb. 1954: Influence of heat treatment and cold work on tensile strength ranges.

STRESSES
See also .. .

Measurement
See also .. .

. . . .

Relief. *See* cross references under Stress Relief

Torsional
See also .. .

. . . .

Visualization. Charts for Stress Visualization. K. W. KINSMAN. MACHINE DESIGN v26n2 Feb. 1954 p 191-3. Charts showing how stresses vary with direction in plane of any two principal planes through point under consideration; using curves presented, designer can keep prominent normal (tensile and compressive) stresses in mind and know where shear stresses tend to become relatively high.

Engineering Index is published annually by Engineering Index Inc. It contains references to articles, papers, and reports in the periodicals and in transactions and bulletins of societies, government bureaus, engineering colleges, research laboratories, and similar agencies received by the Engineering Societies Library. "All of these publications are received," states the preface to the seventieth edition, "and permanently bound by the Engineering Societies Library and are available for personal reference or through photoprint service."

More than 1200 publications, many from foreign countries, are reviewed. Not necessarily all the articles in all these publications are indexed. Only those dealing with engineering are selected. The references for these, however, make an annual volume of about 1280 pages. There is an author index at the end of the volume.

Each reference in the index has a brief summary of the article, and there are many cross references from each subject heading to others. In classifying the articles by subject, the index uses the thing-process breakdown. Sometimes this system is reversed and a process-thing breakdown is used where the process seems of greater importance. Subjects such as Materials Handling, Lubrication, and Air Conditioning are of this kind and aid rather than inconvenience the literature searcher.

Two examples of typical references together with the subject headings and subheadings under which they occur are shown in Table 2. With such complete cross-referencing, there should be little difficulty in discovering the subject headings which

are likely to list material of value. Sometimes the cross references may even suggest new approaches or additional considerations. The short summary given with each reference will usually enable the engineer to decide whether the article will be of value to him without actually securing and reading it.

4—Abstracts

A dictionary definition of an abstract is "that which comprises or concentrates in itself the essential qualities of a larger thing." When applied in actual practice to engineering and scientific articles or reports the abstract may take many forms. It may be a very brief indication of contents, an outline, a critical summary or a long review.

A number of journals are devoted exclusively to abstracts in one form or another. Other publications contain abstracts along with their main editorial material. Some of the professional societies maintain abstracting services and many large companies compile abstracts for themselves. The sources of abstracts are many and varied. The engineer's problem is to discover and become familiar with those containing abstracts which cover the types of information he most often desires.

A most comprehensive guide to such sources is the *Index Bibliographicus* of the United Nations Educational, Scientific, and Cultural Organization. Subtitled a *Directory of Current Periodical Abstracts and Bibliographies,* it was compiled along lines laid down by an international conference on science abstracting which met in June, 1949. It was issued in 1952 as Publication No. 863 of Unesco, whose publications are distributed in the United States by the Columbia University Press, 2960 Broadway, New York 27, N. Y.

Volume I, which is devoted to Science and Technology, lists the essential information about the abstracts and bibliographies appearing in approximately 1500 publications in nine or more languages. The Index itself is printed in parallel columns of English and French.

The main catalog of the Index is arranged under subject headings according to the Universal Decimal Classification but the degree of classification adopted was determined by the material available. Typical listings from the catalog appear in Table 3.

5—Bibliographies

The engineer—especially the engineer who is dealing for the first time with a new kind of problem—may know what he wants in the way of a book or article without knowing where it is or even without being sure that it exists. Bibliographies are designed to meet this need.

Bibliographies are of many kinds: some list only books, others only periodical articles, still others include both. Some bibliographies are carefully selective while others attempt to be comprehensive for their subject or field. Some annotate each item in detail and some attempt to evaluate, but others simply list the items. Each type has its own use, but all types have the advantage of putting the engineer in touch with what has already been published on the subject. A good bibliography reveals sources of information which eliminate the need

An article, "Design Evaluation," by J. S. McChesney, with illustrations and diagrams appeared in *Machine Design,* Volume 27, pages 142-9, the April 1955 issue.

A book, *Dynamics of Machinery,* by A. R. Holowenko, containing 464 pages and priced $7.50, was published by John Wiley & Sons of 440 Fourth Avenue, New York 16, in 1955.

This article appeared in three issues of *Machine Design:* Volume 26, pages 154-60, the October, 1954 issue; Volume 27, pages 183-9, the January, 1955 issue; and Volume 27, pages 158-66, the April, 1955 issue.

Note that this article has a bibliography and is to be continued in future issues.

INDUSTRIAL ARTS INDEX 179

Magnesium; a light weight, machinable metal for low cost tooling. R. L. Nelson. il Tool Eng 34:113-17 Ap '55

Multiple clamping vise jaws. L. H. Bobbitt. diags Tool Eng 34:84 F '55

questions about jigs and fixtures, ref- Mach 99:159 Ap 11

Pneumatic [illegible] drives machine or process 26:206-7 My '55

Design

Design evaluation. J. S. McChesney. il diags Machine Design 27:142-9 Ap '55

Designing dependability and safety into transfer machines; abstract. J. H. Mansfield. il Tool Eng 34:218-20 Ap '55

Dynamics of machinery. A. R. Holowenko. 464p $7.50 John Wiley & sons, 440 Fourth av, New York 16 '55

Mechanical adjustable-speed drives. L. F. Spector. il diags Machine Design 27:168-99 Ap; 178-94 Je '55

Multiple-circuit switches. K. A. Carlson. il diags Machine Design 26:154-60 O '54; 27: 183-9 Ja; 158-66 Ap '55

Plate cam design. M. Kloomok and R. V. Muffley. bibliog diags Product Eng 26:156-62 F; 155-60, insert My '55 (to be cont)

Some applications of experimental psychology to machine design. A. Chapanis. il diags Machine Design 27:212-14 Ap '55

Ultrahigh rotational speeds in a centrifuge by tribelt suspension technique. il diag Machine Design 27:148 My '55

Exhibitions

British industries fair, Birmingham and London, May 2-13. il Engineer 199:590-2, 620-1, [illegible] '55; Engineering 179: [illegible] '55

Automation and its requirements. Murie. il S A E J 63:33-4 My '55

Automation for aircraft; rivets by the millions. E. W. Bergere. il diags Automotive Ind 112:70-1 F 15 '55

Automation for small shops can be practical. G. H. DeGroat. il diags Am Mach 99:113-28 F 28 '55

Automation in hosiery finishing; Proctor & Schwartz Electrocolorset machine. il diag Mod Textiles Mag 36:53+ My '55

Automation in the automobile industry. R. H. Sullivan. Comm & Fin Chr 181:1836 Ap 21 '55

Automation is here, so adjust your sights. C. Brunetti. Comm & Fin Chr 181:2081 My 5 '55

Fig. 5—A representative page of *Industrial Arts Index.* Notes emphasize the features of listings.

for time-consuming or expensive investigation or developmental work.

Every bibliography is, of course, somewhat out of date shortly after it is published. It is still very useful, though, and will save the engineer considerable time, for it sets definite limits to his searching task. He need only look for items more recent than the period covered by the bibliography. Also, it often happens that one bibliography will refer to others in related subjects.

The bibliographies themselves may be discovered in a number of ways. Reference has already been made to their occurrence in *Industrial Arts Index,* and to the notations regarding them on the library catalog cards. In some libraries, the card catalog will have a subdivision marked "bibliographies" under many of the subject headings.

Bibliographic Index is an important source. It is published semi-annually by the H. W. Wilson Co. with a bound cumulation each December. It does for bibliographies what the *Industrial Arts Index* does for periodical articles. Regular examination is made of about 1500 periodicals in search of bibliographical material, and the bibliographies found in books are also included. Arrangement of the *Bibliographic Index* is by subject.

A World Bibliography of Bibliographies, by Theodore Besterman, is another important reference. Volume I, A-E, and Volume II, F-N, of the "Third and Final Edition" were published in 1955. Volume III will follow. About 80,000 volumes, arranged under some 12,000 headings and subheadings, are recorded and separately collated. The work is restricted to bibliographies published separately, and its entries are arranged by subjects.

6—Reference Books

Guide books, encyclopedias, handbooks, and dictionaries are all included in this group. They are books to which one refers for information on one or a very few of the many subjects or specific items treated.

Guide Books are truly keys to other information. They are actually books about reference books and the other keys to the library. They usually contain annotated references to carefully selected reference books, bibliographies, abstract sources, and indexes for their particular field. Some of them, such as the following one by Parke, include excellent material on methods of study, literature searching, and library usage. Among the best of them are:

Parke, Nathan Grier III. *Guide to the Literature of Mathematics and Physics* including related works on engineering science. McGraw-Hill, 1947.

Although this book primarily concerns mathematics and physics it is also useful for a number of engineering subjects, especially electrical, radio, mechanical, and aeronautical engineering.

Part I has excellent material on literature searching and includes a discussion of the principles of reading, study, and self-directed education at the graduate level.

Part II is an annotated bibliography of some 2300 titles arranged by subject.

Dalton, Blanche H. *Sources of Engineering Information.* University of California Press, 1948.

This is a guidebook and bibliography planned to aid the finding of material in all branches of engineering. It contains references to indexes, abstracts, periodical lists, bibliographies, and reference books with a short discussion or comment in each section. The final section includes a list of the thirty or more national standardizing bodies.

Collison, Robert L. *Bibliographies,* Subject and National. A Guide to their Contents and Use. Hafner Publishing Co., 1951.

This book is described by its author as "an informal bibliography of bibliographies" in which he has "tried to draw attention to the qualities and uses of the best bibliographies." A wide range of subjects is covered and individual items are carefully selected.

Encyclopedias provide for the engineer a helpful source of information. The articles are intended to augment knowledge. Unlike handbooks, encyclopedias explain and develop a concept rather than supply data. Because of this emphasis, the encyclopedia article frequently provides an excellent preliminary approach to a new subject. An engineer faced with the problem of designing for manufacture in a material he had never worked with before might find in an encyclopedia article on that material just the preliminary knowledge he needed. He could then go on to more advanced or detailed study in other literature. Here again, the encyclopedia could be of real help, for its principal articles usually close with a short, selected bibliography.

Textbooks are not reference books, but they may be mentioned along with encyclopedias. Textbooks develop an understanding of a branch of knowledge instead of supplying precise information on a number of limited subjects. The engineer may use a textbook to gain an overall picture of an unfamiliar field.

Handbooks are the reference books most familiar to the practicing engineer. Although not an adequate substitute for education or experience they provide, in a compact and convenient form, much of the data and principles needed in day-to-day work with engineering problems. Unlike the encyclopedia, the handbook places emphasis upon facts rather than concepts. Each article or table is a

Table 3—Forms of Entries in *Index Bibliographicus*

Selected from Volume I, Science and Technology, Third Edition, March 1952

Key: c = publication intends to cover its field comprehensively
s = publication intends to cover its field selectively
1750 (or other figures) = the approximate annual number of entries
a = publication presents abstracts
b = publication presents bibliographical entries
i = abstracts are indicative
d = abstracts are informative (= detailed, d)
12 (or other figures) = the number of issues a year

Aslib booklist: monthly recommendations of recently published scientific and technical books (s 900 aib 12). Aslib, 4 Palace gate, London, W.8, England.

Guide to Russian scientific periodical literature. Brookhaven national laboratory (s6500aib9). Technical information branch, U.S. AEC., P.O. box 'P', Oak Ridge, Tenn., U. S.

U. S. Government research reports. Office of Technical Services: U. S. Department of Commerce (s4000ai12). Washington 25, D.C., U.S.

factual unit, and any concepts it contains only serve as a framework for the facts.

Dictionaries should not be forgotten as a good reference tool for the engineer. In science and technology the definitions of words are of basic importance and the engineer needs to know special as well as general meanings. Even a general dictionary, if it is the large unabridged type such as *Webster's New International Dictionary,* may be of great help. In such a dictionary the general definition of a word is often followed by the one or more special or specific meanings it may have in particular fields.

Besides the general dictionaries, there are many dictionaries of special terms which give the more specific definitions and differentiations of terms which apply to the particular field or fields of science or technolgy which the dictionary intends to cover.

7—Personal Assistance

A valuable service to the engineer is the personal assistance of the librarian. Many librarians, particularly those serving engineering, have a surprisingly large qualitative knowledge. They may not be able to answer the engineer's question but they can often save him time by directing him to material he needs.

8—Interlibrary Loans

Few libraries can afford to acquire all the literature their patrons would find useful — not even all material in special fields. Consequently, there has evolved a widespread system of co-operation which has produced union catalogs, union lists of serials and interlibrary loans. Through these, local librarians can determine just which libraries have the books or periodicals needed. Engineers should ask their local librarians to borrow from libraries at a distance rather than request the material themselves. This assures that regular library practices are followed.

9—Microfilm and Photostats

Purchase of microfilm or photostat copies is often a better way to obtain material from distant libraries than interlibrary loan of the original material. Most of the larger libraries either have their own photo laboratory or have arrangements to make copies.

The engineer will often find that it will cost no more to buy a microflim copy of the article he wants than the postage would be for the interlibrary loan. If his own office is not equipped with a microfilm reader he can usually use one in a local library. Photostats are more expensive than microfilms, except for short items, but they have the advantage that they can be read directly.

Either type of copy has the important advantage for the engineer that he does not have to return it. For the library there is the advantage that there is no risk of loss or damage while the material is on loan. In fact, there are many items which a library will refuse to loan.

In addition, the engineer may find a number of items in the reference collection of his local library which he will want copied. This is particularly useful for such items as schematic diagrams and tables of data.

10—AEC Industrial Information

Another service, although available in only a few libraries, should be mentioned because of its possible importance. This service is provided by the Industrial Information Depositories established by the U.S. Atomic Energy Commission. In addition to the collections of AEC reports now available in the 40 or more AEC Depository Libraries throughout the country, additional information is available at a few libraries selected to serve as industrial depositories. These libraries "will have available collections of engineering drawings and certain other materials of special interest to industrial requesters. All such materials will be in a form suitable for the preparation of copies so that requesters may purchase copies for retention. To date five industrial depositories have been established:

Atomic Industrial Forum, Inc.
260 Madison Avenue
New York, New York

Office of Technical Services
U.S. Dept. of Commerce
Washington 25, D. C.

Georgia Institute of
Technology Library
Atlanta, Georgia

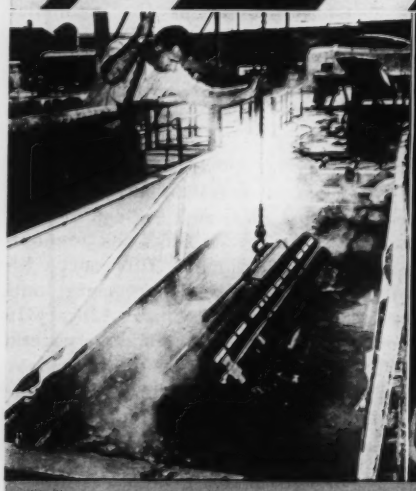
John Crerar Library
86 East Randolph Street
Chicago, Illinois

Stanford Research Institute
Stanford, California

This quotation and other useful information about AEC Reports may be found in the pamphlet "Availability of USAEC Research and Development Reports," TID-4550 (Revision No. 2), Sept., 1954, published by the USAEC Technical Information Service, Oak Ridge, Tenn.

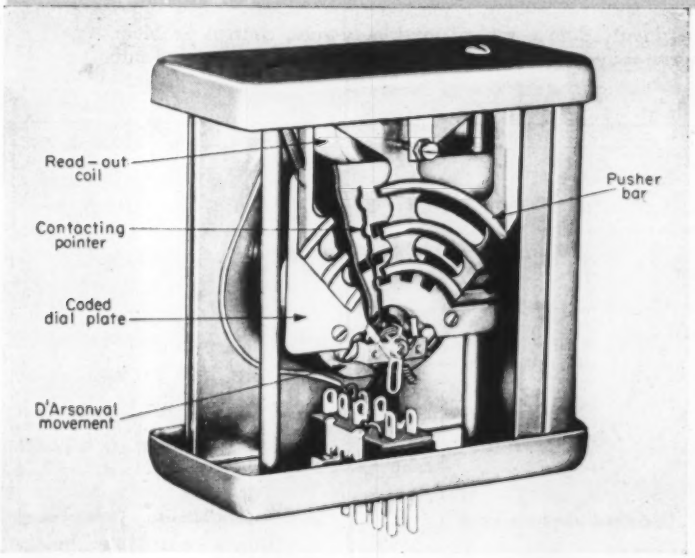
Conclusion: In putting library keys to use, the engineer will not want to overlook any of the libraries which may help. It is well to keep in mind the four principle types: Special Libraries, predominantly one-subject collections; University Libraries, usually subdivided into departments; outstanding libraries, like the John Crerar Library in Chicago, devoted to science and technology; and large public libraries. Many public libraries have a special collection of scientific and technical material housed in its own section with its own personnel. Eventually, the engineer will find that the usefulness of library skills are worth his effort to obtain them.

scanning the field for Ideas



CHEMICAL "MILLING" OF METAL parts offers a practical approach to forming of intricate and complex contours. In the Chem-Mill process, originated by North American Aviation and developed in conjunction with Turco Products Inc., metal parts have been "etched" to close tolerances. Originally confined to aluminum alloys, the process is now also being successfully applied to steel and titanium parts.

Basically, the process consists of first submerging the parts to be etched in five cleaning baths. Parts are then masked mechanically, or with tape, or by a spray-coat through a template. After passing through an etching tank, the chemically milled parts are rinsed in cold water. Finally, they are dipped in solutions to remove smut and masking material and rinsed in hot water.



Printed – Circuit Scale

BINARY CODED SCALE on electrical meter dials permits conversion of analog input data to a digital output. In a unit designed at Assembly Products Inc., a D'Arsonval coil positions the contacting pointer in the same manner as for a standard indicating meter. A printed-circuit scale is employed that may contain from one to six segmented contact bands. When the read-out coil is energized, the pusher bar moves the contacting pointer down on the printed-circuit scale. This action produces a binary output by means of a unique combination of circuit closures that is dependent upon pointer position and the printed-circuit scale pattern.

AUTOMATIC OVERLOAD CLUTCH design utilizes a novel toggle-linkage method of release when load exceeds a predetermined value. Developed by Joseph M. Kalafsky, Cleveland, O., the design permits either manual or automatic resetting.

In construction the mechanism consists of a knee-jointed toggle linkage mounted on a driving member (not shown) and a spring-counterbalanced lever arm mounted on the driven member. Under normal load conditions, the free end of the toggle is engaged with and transmits driving power to the lever arm. In the event of an overload, the lever arm is forced by the toggle to pivot and, in turn, stretch the counterbalance spring. Relative rotation develops between driving and driven members, and the driven end of the lever arm is moved toward the center of the driven member. These displacements cause the knee-jointed toggle to straighten to the point where it immediately collapses and snaps away releasing the driving power.

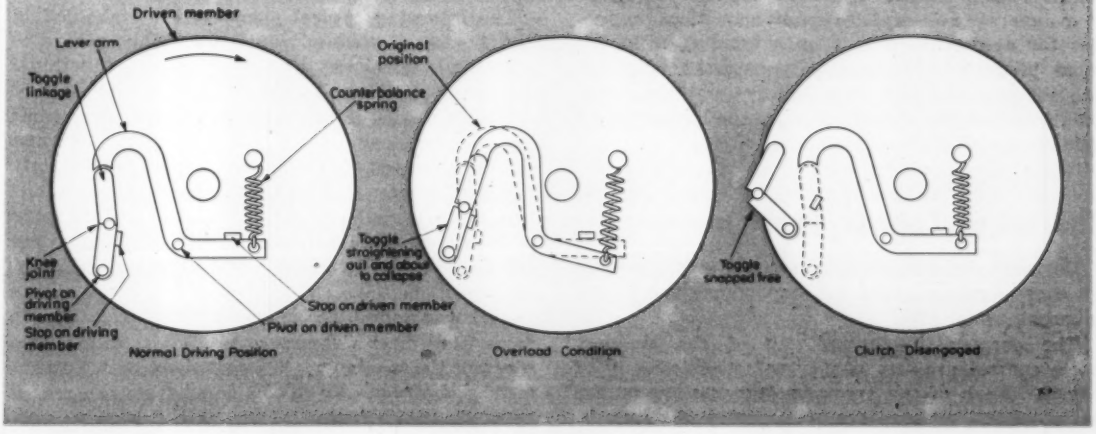
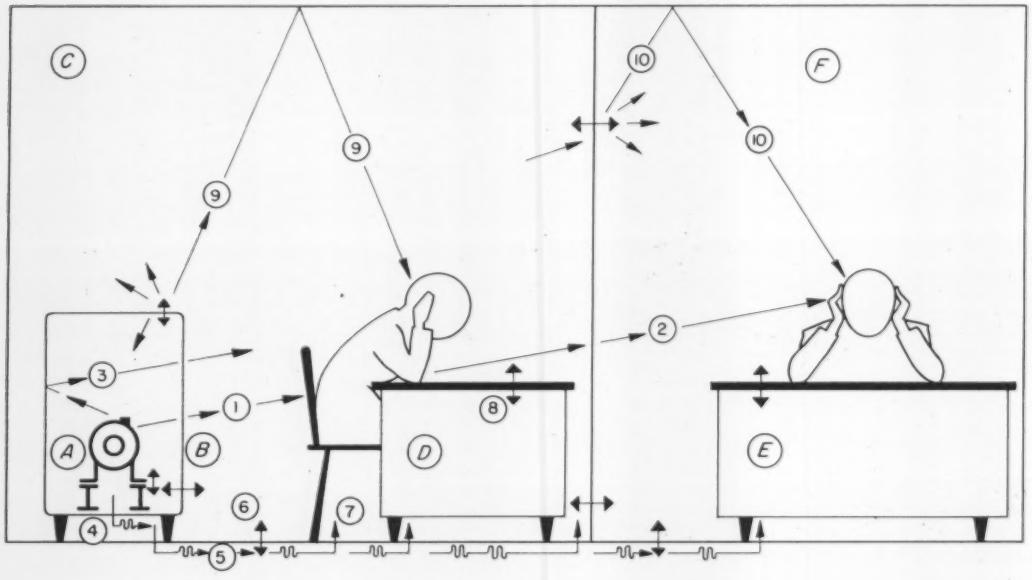


Fig. 1—Disturbance paths involved in a typical machinery-noise control problem. Airborne and structure-borne sounds, generated by the machine are propagated into the environment.



How to Use

Acoustical Materials

NO SPECIAL class of materials can be singled out and labeled unambiguously "acoustical materials." More precisely, every material in existence has properties with acoustical ramifications. Special materials are manufactured to exaggerate and exploit certain acoustical properties for application where an overriding need for these properties has been demonstrated. But no one magical material can satisfy simultaneously all of the needs encountered in the problems of noise and vibration control.

The Noise Control Problem

Current emphasis on noise control is justified by its ever-increasing practical importance and by its inherent complexity.

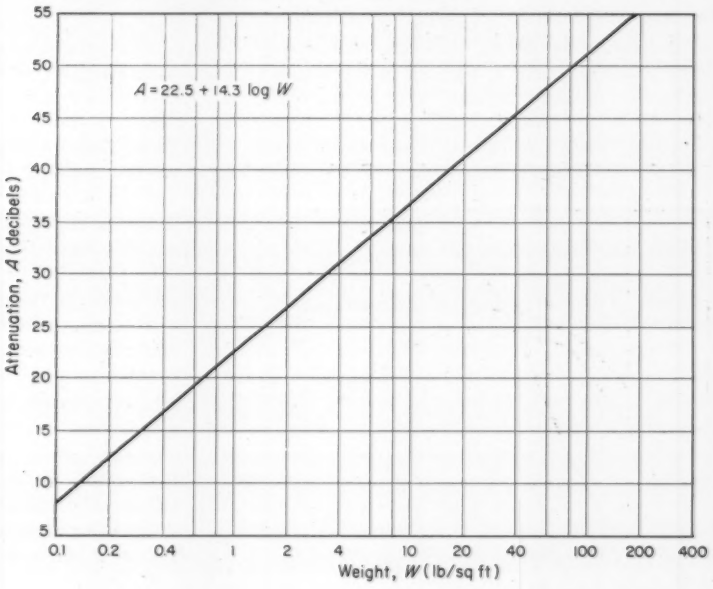
The exasperating complexity of the simplest noise control problem is pictured schematically in Fig. 1. Each of the arrows represents one of the paths of disturbance from the noisy machine to the distracted thinker. Each of the arrows implies the need for a particular application of an acoustical material. Quite evidently, the acoustical property required in one place may be entirely different from that required elsewhere.

The following typical elements are embodied in Fig. 1: *A*, a machine which inevitably generates noise and vibration; *B*, the machine's functional enclosure; *C*, the architectural enclosure around the machine; *D*, the hapless occupant of the room; and *E*, the desk of the more remotely situated thinker, located in room *F*, either immediately adjacent or more remote.

A cursory analysis of the various possible paths of vibratory disturbance from the machine to the observers would involve several modes of propagation.

Airborne sound, for example, is emitted directly from the machine components and transmitted through the machinery housing along path 1 to the nearby observer. From this point, it is transmitted through the partition along path 2 to the more

Fig. 2—Transmission of sound through a homogeneous simple partition. The average attenuation of sound in a frequency band centered at 500 cps is approximately related to the surface density of the partition by the simple "weight law" shown.



A review of the engineering factors involved in selecting materials for the four important methods of noise control: sound-transmission attenuation, sound absorption, vibration isolation, and vibration damping.

By Richard N. Hamme

Research Physicist
Engineering Research Institute
University of Michigan
Ann Arbor, Mich.

for control of noise and vibration

remote observer. Increasing the *sound-transmission loss* of the machine-housing walls and/or of the partition would reduce this source of disturbance.

Airborne sound emitted from machine components is often reflected by the housing walls along paths analogous to 3. Ultimately these contributions supplement those transmitted directly along path 1. If there were no sound-energy absorption within the machine enclosure, these internal reflections build up the noise level to the point where sound transmitted outward is sensibly the same as if no enclosure were present. Evidently, some provision must be made for *sound absorption* within the enclosure in order to derive benefit from the source enclosure.

In addition to emitting airborne sound, the machine produces structural vibration which can be conducted as structure-borne sound through the machine mounts along path 4 to the housing walls. Vibrations of the housing panels radiate noise outward into the room—noise which is almost indistinguishable from the airborne sound transmitted directly through the panels. Either interruption of the conduction path to the panels (*vibration isolation*), or reduction of the susceptibility of the panels to vibratory excitation (*vibration damping*), is helpful.

Evidently, any vibration from the machine which reaches the housing is likely to be conducted to the floor along path 5, there to be radiated into the room as airborne sound at 6. It is then conducted into the local environment of the nearby observer along path 7, producing local airborne radiation at 8. Sound reaches the remote observer along similar paths.

Such vibrations can be isolated at any convenient point along the conduction paths, and can be damped at each of the potential radiating surfaces. Vibration paths and locations remote from the source must be considered — even though the vibrations become progressively less intense as they spread through a structure. There are two reasons: the obvious importance of airborne sound

radiated at points close to an observer, and also the very serious possibility of resonance, a condition which produces loud noises from weak forces of excitation. It may be expected that, in the absence of perfect vibration isolation, there may be need for extensive vibration damping.

The acoustic problem in Fig. 1 is further complicated by paths 9 and 10, along which airborne sound entering a room, redirected by reflections, reinforce the direct disturbances. This possibility points up the need for sound absorption at the room surfaces in order to reduce the intensity of reflected sound.

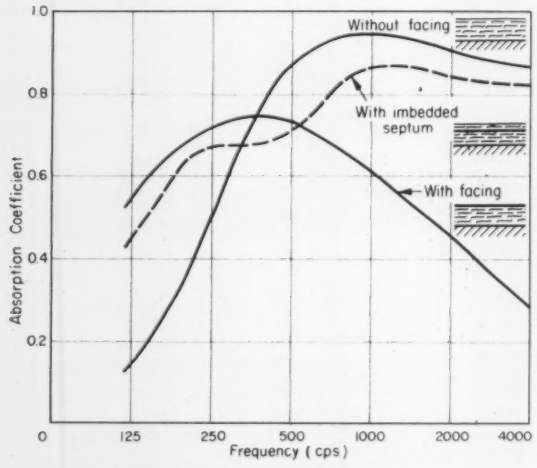


Fig. 3—Influence of an impervious septum on the sound-absorption characteristics of a thick, fibrous blanket. Low-frequency absorption can be enhanced at the expense of the high-frequency absorption.

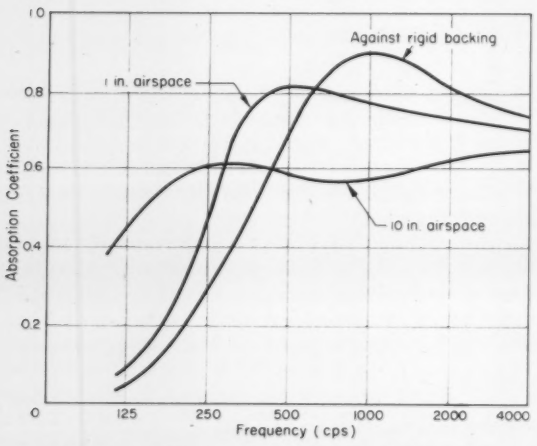


Fig. 4—Influence of an entrained airspace on the sound-absorption characteristics of a thin, fibrous blanket. Greater depth of airspace increases low-frequency absorption but decreases the abrosption at high noise frequencies.

Noise Control Materials

The preceding analysis of a typical noise-control situation shows the need for materials or configurations with four distinct capacities: (1) absorption of airborne sound, (2) isolation of airborne sound, (3) isolation of vibration, and (4) dissipation of vibrational energy.

As a first approximation, experimental findings show that good sound-absorbing materials are characterized by lightness and porosity. Good sound-isolation materials are generally massive and impervious. Good vibration-isolation materials have high resilience. And good vibration-damping materials possess high mechanical hysteresis.

Fibrous materials, which absorb sound well, generally transmit sound readily. Metallic partitions, which resist sound transmission, are generally undamped and provide little sound absorption. Rubberlike materials, which are good vibration isolators, generally provide little damping. And so it goes through a long list of contradictions to the idea of a magical acoustical material.

Evidently, the four mechanisms required in noise control must be provided by judicious combinations of materials, each individually selected for its

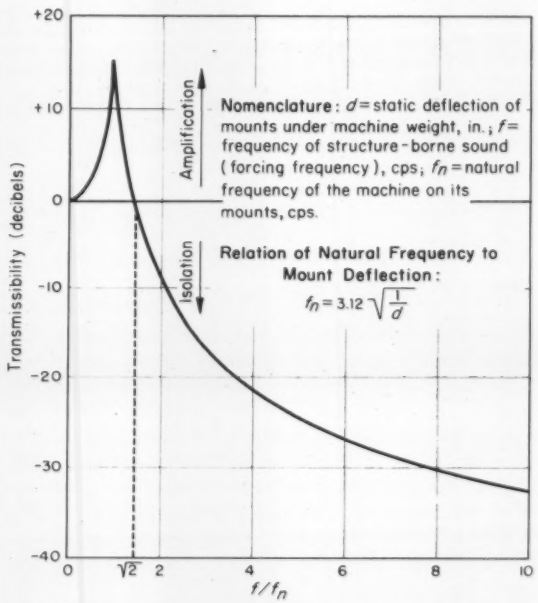


Fig. 5—Typical design curve for resilient mount selection. Note that isolation is achieved only at frequency ratios higher than the dashed line.

exaggerated performance in one respect. Composite performance must be derived from special configurations designed to exploit separate properties of each material. Composite treatments can be designed from published properties of acoustical materials, with the help of certain approximate operational rules.

Sound Transmission: Sound transmission through a partition is expressed in terms of the fraction of incident sound energy that is transmitted. The measurable quantity here is the sound attenuation in decibels for randomly incident sound.

For homogeneous partitions that are adequately damped, measurements show that the empirical law represented in Fig. 2 is, as a first approximation, equally applicable to all nonporous materials. Attenuation is a simple function of weight per unit area of the partition material. Attenuation depends upon the frequency of incident sound, low frequencies being transmitted more readily than high frequencies at the rate of about 6 decibels per octave.

Lack of adequate damping will cause poor attenuation at the natural frequencies of the panel. These frequencies depend on the particular panel dimensions selected. Practical examples of efficient partition materials include damped sheet metals, high-density building boards, solid masonry, hard plaster, etc. Notorious misapplications include fibrous boards, perforated metals, and cinder block. Multiple partitions are of great value, provided they are suitably isolated, i. e., providing the mechanical connection between them is resilient to ensure vibration isolation of one from the other, and providing the air space between them is deep enough to ensure independent vibration of the panels.

Sound Absorption: Sound-absorbing capacity of a surface treatment is expressed in terms of its sound-absorption coefficient as a function of frequency. The practical, measurable quantity is the random-incidence absorption coefficient measured by the reverberation-room method.

Absorption coefficients of materials are complicated functions of thickness, density and air-flow resistance of the materials and profoundly depend upon their surface covering and the depth of airspace behind the absorbing layer. Figs. 3 and 4 demonstrate the design latitude available with the use of a specified material.

Practical examples of sound-absorbing materials include fibrous blankets of many kinds, mineral and fiber tiles, loose fibers in batts, acoustical plasters, and perforated metals and hardboards backed by absorbing materials. These are the so-called "acoustical materials." Notorious misapplications include perforated, louvered, or open areas with a rigid backing, stretched wires, and mechanical resonators tuned to the wrong frequency.

Vibration Isolation: The isolation effectiveness of a resilient mounting or coupling is expressed in terms of its force transmissibility. The practical quantity measured is the so-called decibel-drop in the vibration velocity level across the isolator.

Both measurement and theory show that isolators can be designed in accordance with Fig. 5, provided the machine foundation is rigid, massive and well damped, and provided conduction waves are interrupted in their travel through the mount material by interfaces with appreciable mechanical impedance mismatch. Typical losses of isolation

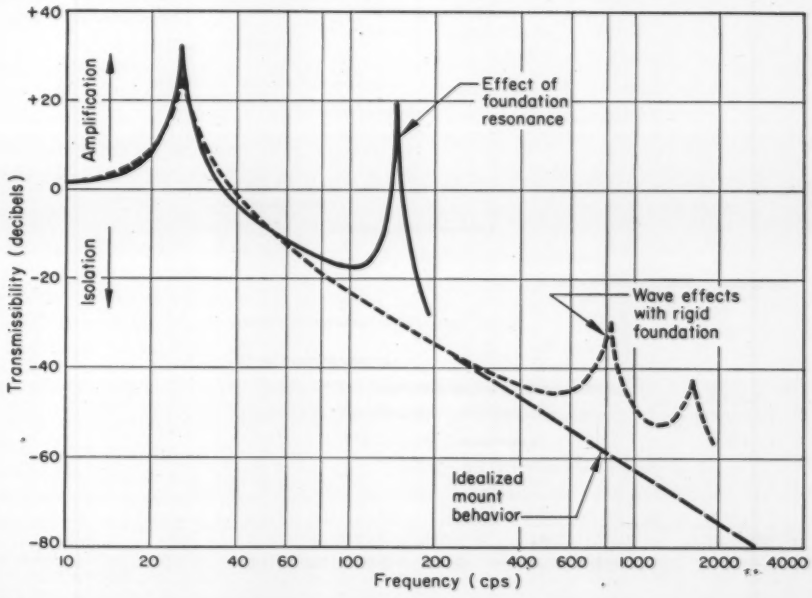


Fig. 6 — Resilient mount "failures." Apparent losses of isolation can occur due to resilience in the machine foundation and conduction waves through the resilient mount. Disregarding such effects can result in amplification of machinery noise at discrete frequencies in the nominal isolating range.

due to foundation resonance and wave conduction are indicated in Fig. 6.

Examples of satisfactory vibration isolators include resilient rubber pads, cork and certain high-density fibrous materials, a wide range of commercial resilient mounts involving rubber in shear and rubber in compression, and metallic springs with suitable attachments to provide damping and to prevent metal-to-metal contact between machine and foundation. Notorious misapplications include

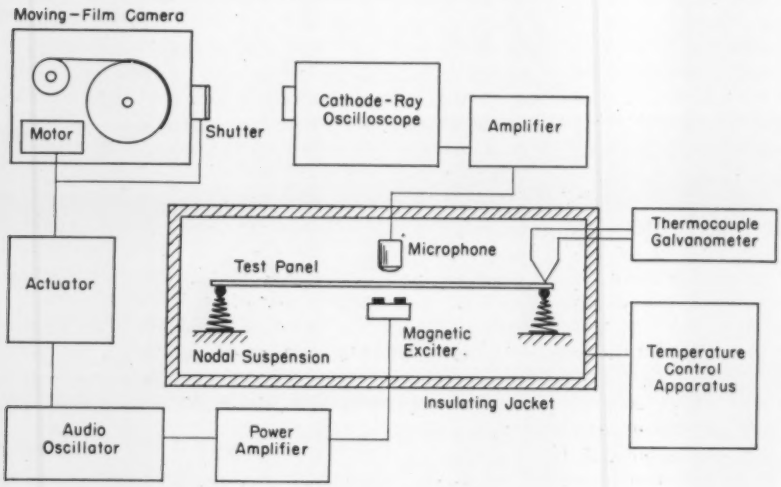
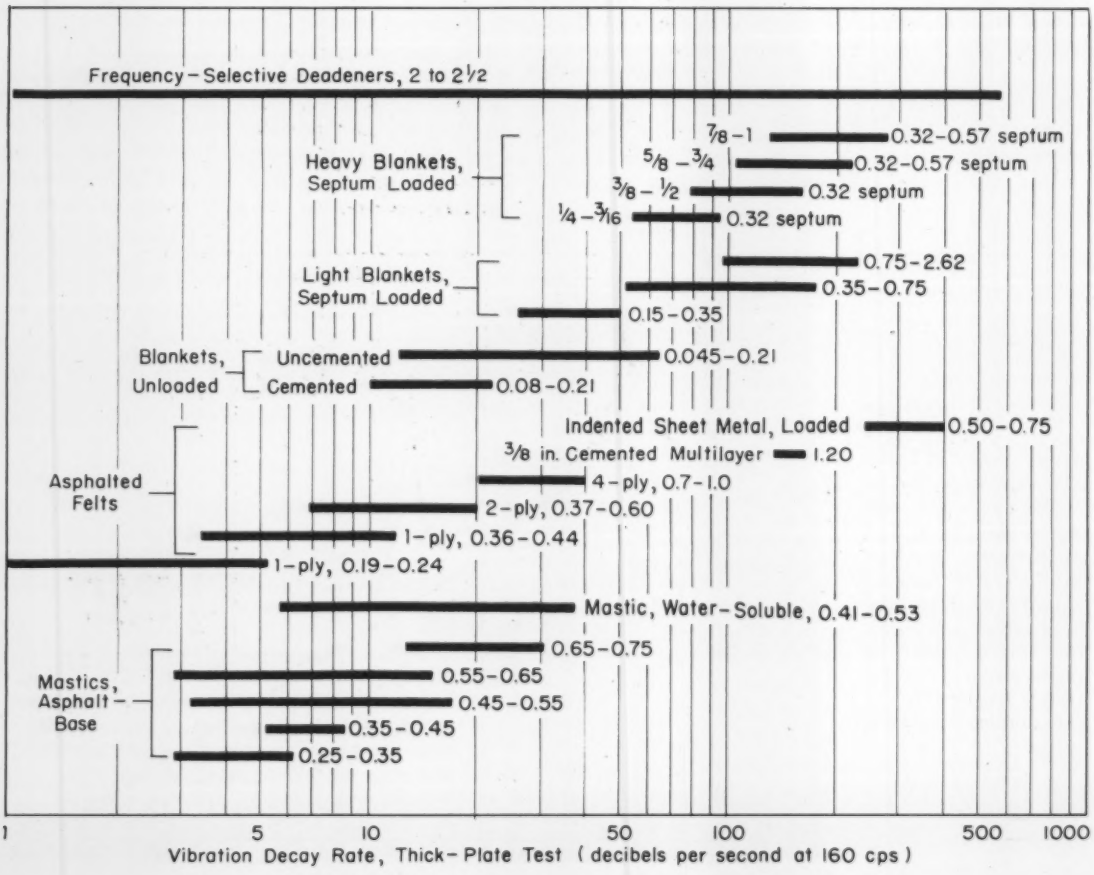


Fig. 7—Left—Apparatus for the comparison of damping capacities of panel deadeners.

Fig. 8 — Below — Comparison of the panel-damping effectiveness of various treatments in terms of the 160-cps thick-plate test. Figures indicate range of treatment weight studied, in lb per sq ft. Results are strictly valid only for room temperature, approximately 70 F.



resilient mountings shorted-out by rigid mechanical connections in the form of piping, conduits and straight-through mounting bolts, and improper selection of mount stiffness.

Vibration Damping: The technology of vibration damping is not well standardized, principally because the practical damping capacity of materials is so dependent upon the mode of vibration excited and the methods of support and fabrication.

Damping inherent to materials is generally negligible in comparison to that derivable from surface treatments or methods of fabrication. For example, the differences between the inherent damping of metals of comparable strength are generally negligible compared to the damping contributed by bolted joints as compared to welded joints, etc. A panel consisting of two layers of 16-gage sheet steel spot-welded together is considerably "deader" than a corresponding ⅛-in. thick solid sheet-steel panel. The deadened panel rings out less after impact and responds less to steady-state vibrational excitation at and near its natural frequencies. These factors are the two of significance in practical noise reduction.

In order to avoid compromises in structural integrity and complications in fabrication, special panel-damping techniques have been developed which do not depend essentially on the material and support of the structural panel. For example, surface layers can be applied for the sole purpose of dissipating the energy of flexural panel vibration which would otherwise produce airborne sound.

Comparison of the damping capacities of surface treatments, as for other acoustical property comparison, requires that the effects of frequency be investigated. In this case, however, the investigation is more difficult since significant damping only occurs at natural frequencies of vibration, either in free vibration after impact or under steady-state excitation at resonance. Hence, comparison of damping treatments requires that the various materials be applied to an arbitrary and standardized vibrating system. Such a standardized system is a ¼ x 20 x 20 in. steel plate suspended nodally and vibrating at its fundamental mode in an anechoic temperature-controlled environment.

The parameter measured is the vibration decay rate in decibels per second at 160 cycles per second, which is the fundamental natural frequency of a plate this size and shape. The apparatus used to accomplish this measurement is shown schematically in Fig. 7. The results of an extended survey of several commercially available materials is shown in Fig. 8.

Besides the relative damping at 160 cps, other factors must be taken into account before a panel-damping treatment is selected for a particular application. Most important among these are the temperature range to which the treatment will be exposed, the range of natural frequencies over which the treatment must be effective, and the weight limitation that may be imposed.

Importance of temperature is demonstrated by Fig. 9, in which the damping effectiveness of two typical mastic treatments is shown to be extremely temperature-sensitive, unlike most other acoustical properties discussed.

Even though Fig. 8 is for thick plates, damping treatments for thin panels can be selected from it. Generally speaking, natural resonant frequencies of thin panels are lower than those of thick plates of the same size. Since effectiveness of the damping material decreases with lower resonant frequencies, more damping material would be required on a thin panel if it were not for its

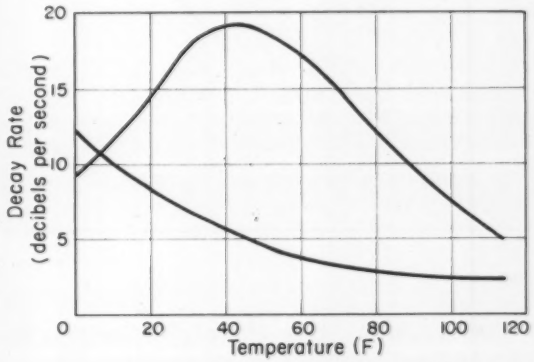


Fig. 9—Temperature dependence of the damping effectiveness of two asphalt-base mastic deadeners, each applied to a dry weight of 0.6-lb per sq ft.

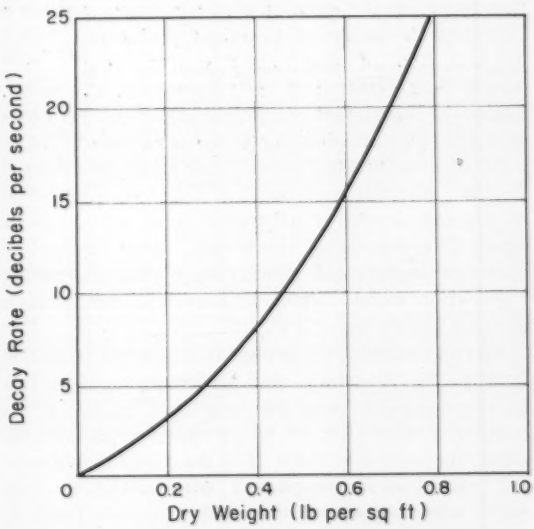


Fig. 10—Influence of application weight on the damping effectiveness of a mastic deadener. Advantage of concentrating a heavier-weight treatment on panel areas of maximum vibration amplitude is evident.

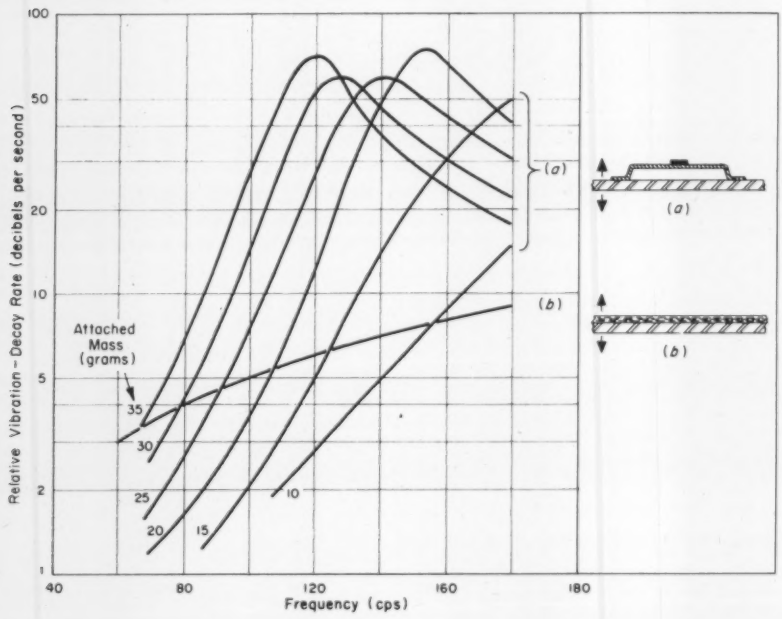


Fig. 11—Comparison of damping capacity of the same material in two different configurations: *a*, a single 3 in. diam disk of material, spaced out from the panel and loaded with the various attached masses shown; and *b*, 400 sq in. of the same material applied conventionally. The frequency-selective character of the spot-damping application permits damping much lower frequencies without excessive increases of treatment weight.

naturally lower mass.

However, if two different configurations have the same natural frequency, the more massive plate will require a treatment of greater damping capacity to accomplish the same noise reduction. The surface damping treatment must produce about the same fraction of critical damping in each case. Thus, in general, the effects of differing mass tend to compensate the effects of differing natural frequency, so the data of Fig. 8 remain applicable over a wide range of practical problems.

Limitation of damping-treatment weight may lead to consideration of partial coverage of a panel. Since the treatment performs its damping function only by participating in panel vibration, treatment of nonvibrating panel areas represents wasted weight. Furthermore, an antinodal concentration of a given weight of treatment takes advantage of another economy of material. Many materials show an increase of effectiveness with increasing application weight which is somewhat better than directly proportional, Fig. 10.

Another variant of antinodal treatment is shown in Fig. 11, in which the performance of a frequency-selective spot-damping configuration is compared with that of an overall treatment utilizing the same materials. The low-frequency damping capacities accomplished with negligible material area and attached weight are quite possibly of sufficient advantage to compensate for the trouble of locating an antinodal attachment point. This is particularly true on production items where large numbers of panels are reproduced with sufficient accuracy to ensure reproducibility of the lower-frequency vibration modes which are the most difficult to damp.

Composite Treatments: Limited space prevents discussion of composite treatments except to mention their possibility. It is obvious, for example, that a single septum-loaded blanket can be devised to perform simultaneously in a vibration-damping and sound-absorption capacity. The otherwise impervious sheet which is used to load the blanket against the vibrating surface need only be perforated to allow penetration of incident airborne sound into the same blanket. Other composite treatments can be devised as well. But the most significant point is still that rational use of acoustical materials depends upon selection from four broad classes of materials the ones best suited to perform the distinct functions required by the specific problem.

Tips and Techniques

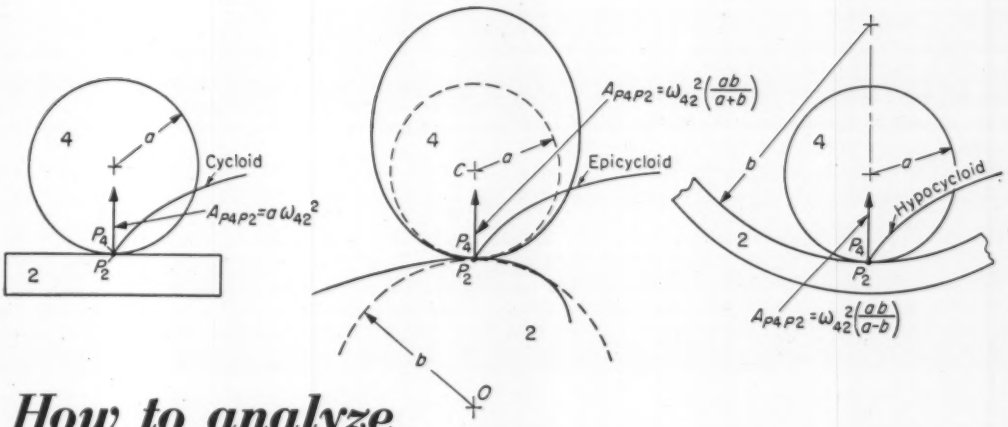
Template for Screw Threads

Drawing of machine screw threads can be simplified by cutting a V-shaped notch in any triangle to use as a template. Time savings are approximately 30 per cent. A notch can also be cut for Acme threads if needed.—HUBERT M. PUGH, *chief engineer, Thermo-Products Inc., North Judson, Ind.*

Correction

In the article "Cycloid Speed Reducer," June 28, 1956, name of one of the authors, D. W. Botstiber, should have been spelled as shown here.

Fig. 1—Paths of relative motion between points P_4 and P_2 for circular and noncircular members with rolling contact



How to analyze

Rolling-Contact Mechanisms

for acceleration characteristics

By Ching-u Ip, I. E. Morse Jr. and R. T. Hinkle

Mechanical Engineering Dept.
Michigan State University
East Lansing, Mich.

IN THE DESIGN of mechanisms having rolling contact, it may be quite important to know the acceleration characteristics of rolling members. For example, angular acceleration-time curves for rolling members can be used to investigate the possibilities of slipping between members. Also, if rolling members have gear teeth, acceleration data can be used to determine tooth loads caused by inertia.

General equations are presented in this article for calculation of relative acceleration of circular or noncircular members rolling in a single plane. Obviously, these members can roll on either straight or curved surfaces as demonstrated in *Fig.* 1. Paths of relative motion of point P_4 with respect to P_2 in the three cases of rolling-contact circles in *Fig.* 1 are either a cycloid, an epicycloid, or a hypocycloid. In acceleration analyses, direct-contact members of noncircular form can be replaced by circular members having radii equal to the contact radii of the noncircular members.* In the center drawing in *Fig.* 1, where both circular and noncircular curves are depicted, the circles of radii a and b can be employed to evaluate the acceleration characteristics of the noncircular

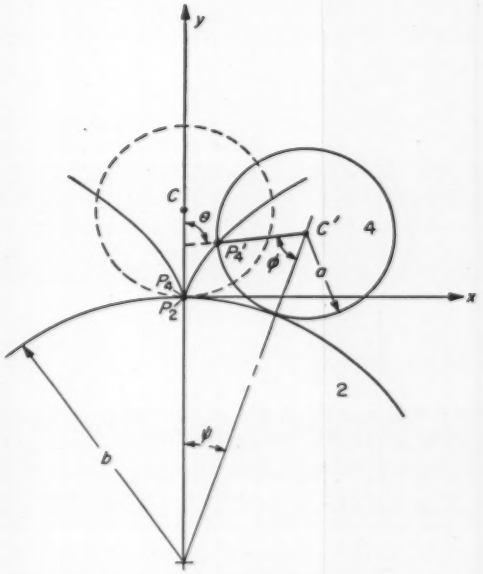


Fig. 2 — Circular member of radius a rolling on another circular member of radius b

*R. T. Hinkle, C. Ip, and J. S. Frame—"Acceleration in Mechanisms," *Journal of Applied Mechanics*, June, 1955.

curves for the phase shown. Therefore, it is necessary to develop equations for circular members only.

Epicycloidal Acceleration: The relative acceleration A_{P4P2} can be obtained by taking the second derivative of the parametric equations of the relative-motion path. The parametric equations for the epicycloid generated by the relative movement of points P_4 and P_2 in *Fig.* 2 are

$$x = (a + b \sin \psi - a \sin \left[\frac{(a+b)\psi}{a} \right] \quad \ldots\ldots (1)$$

and

$$y = (a + b) \cos \psi - a \cos \left[\frac{(a+b)\psi}{a} \right] \quad \ldots\ldots (2)$$

The amount of relative acceleration A_{P4P2} at position $\psi = 0$ is desired. The geometrical relationships for pure rolling are

$$\phi = -\frac{b\psi}{a} \quad \ldots\ldots (3)$$

and

$$\theta = \phi + \psi \quad \ldots\ldots (4)$$

where θ is the angle rotated through by the radius a from position CP_4 to $C'P_4'$. The angular velocity of body 4 relative to 2 is

$$\omega_{42} = \frac{d\theta}{dt}$$

Substitution of the Equation 3 value of θ into Equation 4 gives

$$\psi = \frac{a\theta}{a+b}$$

With this value of ψ, Equations 1 and 2 then become:

$$x = (a + b) \sin \left(\frac{a\theta}{a+b} \right) - a \sin \theta \quad \ldots\ldots (5)$$

and

$$y = (a + b) \cos \frac{a\theta}{a+b} - a \cos \theta \quad \ldots\ldots (6)$$

The x and y components of the relative velocity V_{P4P2} are given by the expressions

$$\frac{dx}{dt} = \frac{dx}{d\theta}\frac{d\theta}{dt} = \frac{d\theta}{dt}\left[a \cos \left(\frac{a\theta}{a+b} \right) - a \cos \theta \right]$$

and

$$\frac{dy}{dt} = \frac{dy}{d\theta}\frac{d\theta}{dt} = \frac{d\theta}{dt}\left[- a \sin \left(\frac{a\theta}{a+b} \right) + a \sin \theta \right]$$

At position $\psi = 0$, $\theta = 0$ gives $dx/dt = dy/dt = 0$ as they should because P is the instantaneous center of velocity.

The second derivatives of Equations 5 and 6 give the x and y components of the relative acceleration A_{P4P2} which are

$$\frac{d^2x}{dt^2} = \frac{d}{d\theta}\frac{dx}{dt}\frac{d\theta}{dt} = \left(\frac{d\theta}{dt} \right)^2 \left[- \frac{a^2}{a+b} \sin \left(\frac{a\theta}{a+b} \right) + a \sin \theta \right]$$

and

$$\frac{d^2y}{dt^2} = \frac{d}{d\theta}\frac{dy}{dt}\frac{d\theta}{dt} = \left(\frac{d\theta}{dt} \right)^2 \left[- \frac{a^2}{a+b} \cos \left(\frac{a\theta}{a+b} \right) + a \cos \theta \right]$$

at the position $\theta = 0$.

The expression for tangential acceleration of an epicycloid is

$${}_tA_{P4P2} = \frac{d^2x}{dt^2} = 0$$

for $\theta = 0$, whereas normal acceleration of an epicycloid is

$${}_nA_{P4P2} = \frac{d^2y}{dt^2} = \frac{ab\omega_{42}^2}{a+b}$$

when $\theta = 0$.

Since the tangential acceleration is zero, the normal acceleration is also the total acceleration for an epicycloid, or

$$A_{P4P2} = \frac{ab\omega_{42}^2}{a+b} \quad \ldots\ldots (7)$$

In *Fig.* 3, an example problem is solved to demonstrate how to determine the angular acceleration of roller 4. Point P_4 moves along the path of an epicycloid with respect to P_2.

Hypocycloidal and Cycloidal Acceleration: By a similar mathematical development the total acceleration for the hypocycloid is

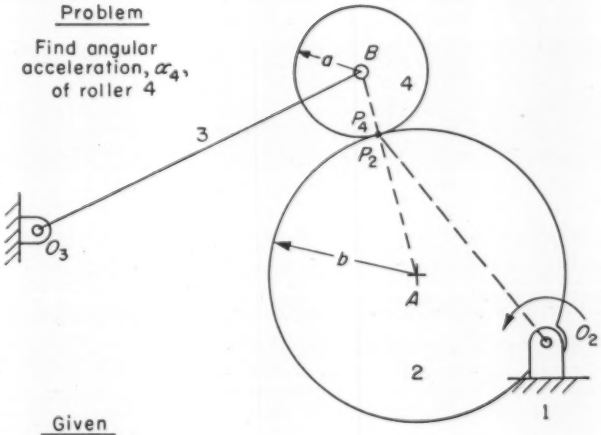
$$A_{P4P2} = \frac{ab\omega_{42}^2}{a-b} \quad \ldots\ldots (8)$$

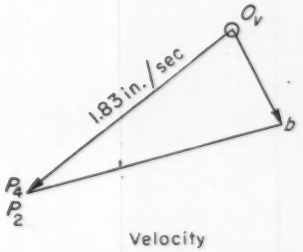
and for the cycloid is

$$A_{P4P2} = a\,\omega_{42}^2 \quad \ldots\ldots (9)$$

For the hypocycloid the acceleration vector is directed toward the center of body 2. The cycloidal formula can also be found from the other two formulas as a special case where b is infinite.

Fig. 3—Example showing determination of acceleration in mechanism having a rolling contact





Given

$a = BP_4 = 0.5$ in.
$b = AP_2 = 1$ in.
$O_3B = 2.5$ in.
$\alpha_2 = 0$ rad/sec^2
$\omega_2 = 1$ rad/sec

Solution

$A_B = {}_nA_B + {}_tA_B$
$= A_{P4} + {}_nA_{BP4} + {}_tA_{BP4}$

Where $A_{P4} = A_{P2} + A_{P4P2}$

${}_nA_B = \frac{V_B^2}{O_3B} = \frac{(0.73)^2}{2.5} = 0.213$ in./sec^2

${}_tA_B$ is known in direction only

$A_{P2} = \omega_2^2(O_2P) = (1)^2(1.83) = 1.83$ in./sec^2

$\omega_4 = \frac{V_{BP4}}{BP_4} = \frac{1.85}{0.5} = 3.7$ rad/sec (c.w.)

$\omega_{42} = 3.7 + 1 = 4.7$ rad/sec (c.w.)

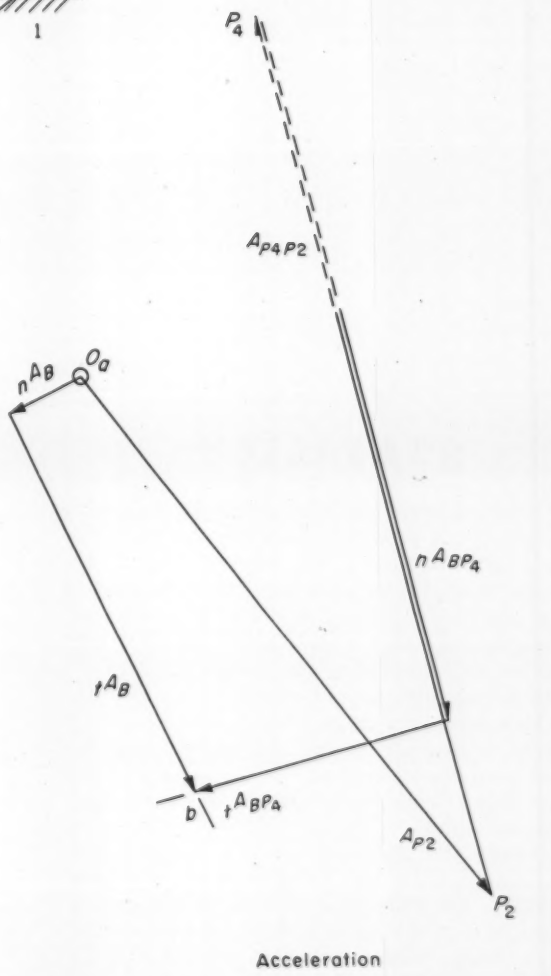
$A_{P4P2} = \omega_{42}^2\left(\frac{a\,b}{a+b}\right) = (4.7)^2\left[\frac{(0.5)(1)}{0.5+1}\right] = 7.36$ in./sec^2

${}_nA_{BP4} = \frac{V_{BP4}^2}{BP_4} = \frac{(1.85)^2}{0.5} = 6.85$ in./sec^2

${}_tA_{BP4}$ is known in direction

From drawing ${}_tA_{BP4} = 0.71$ in./sec^2

$\alpha_4 = \frac{{}_tA_{BP4}}{BP_4} = \frac{0.71}{0.5} = 1.42$ rad/sec^2 (c.c.w.)



Criteria for

Evaluating Servo System

By J. M. Nightingale
Manchester, England

METHODS of assessing servo system performance with a view to obtaining optimum design values for the various system parameters will be outlined in this article. Earlier articles in the co-ordinated group of which this article is a part established the relationship of servo systems, servomechanisms and other automatic control systems.[1] Additionally, an introduction to the advanced mathematical techniques necessary to servo analysis was made.[2]

Performance can be described generally in terms of two qualities: (1) stability and (2) response. Stability describes the ability of a servo to settle down after a disturbance has been removed. It is closely related to the response of the system. Response is the term used to describe the accuracy and sensitivity of the system when responding to some input or command signal.

STABILITY

The formal definition of a stable servo is very clear-cut. It is a system in which the output is always finite, or limited, for any finite input. An unstable servo is one in which the output drifts away from the input without limit. This does not necessarily happen for all inputs, but if it will occur for any input then the system is obviously unsatisfactory. The idea of output increasing without limit is only a mathematical concept. What happens in practice is that output will only increase until some component in the system breaks down, or until some nonlinearity intervenes to constrain the output.

Although this definition gives a definite division between stable and unstable servos, the term stability is generally used in a relative sense. A system with good relative stability characteristics, Fig. 1*a*, might have a maximum overshoot of 0.3 and its oscillations would decay in a comparatively short time such as four times the buildup time. On the other hand, a system having a maximum overshoot of 0.8 and a decay time equal to ten times buildup time, Fig. 1*b*, although stable in an absolute sense, would be said to have poor relative stability characteristics.

The mathematical definition of stability is that

$$\int_0^\infty | W(t) | \, dt$$

must exist and be finite, where $W(t)$ is the weighting function.[2] In practical servos a sufficient condition is that $W(t) \rightarrow 0$ as $t \rightarrow \infty$. Physically this means that the output must return to its initial position if the system is given a sudden impulsive kick at the input.

The most general expression for $W(t)$, the weighting function is

$$W(t) = (A_1 + B_1 t + C_1 t^2 + \ldots)\, e^{h_1 t} + (A_2 + B_2 t + \ldots)\, e^{h_2 t} \qquad (1)$$

where h_1, h_2, etc. are all the values of s which make $G(s)$, the denominator of the overall transfer function, $Y_c(s)$, zero. Each h may be either real, imaginary, or in the most general case complex. Any complex root can be written in the form $h = \alpha + j\Omega$. Presence of such a root indicates a damped sinusoid in the weighting function. Only if α is negative will this oscillation decay as time t increases. Thus, a necessary condition for stability is that *all the roots of* $G(s) = 0$ *must possess a negative real part.*

Note that in practical systems the coefficients of powers of s in $G(s)$ are positive and real. This implies that complex roots occur in conjugate pairs. That is if $\alpha + j\Omega$ is a root, then $\alpha - j\Omega$ is also a root.

The presence of a purely imaginary root, say $s = j\Omega_o$, is to be deplored. It does not satisfy the above condition for stability and means that there is an undamped oscillation in the weighting function. With a periodic function input of frequency Ω_o, the output can increase without limit, at least in theory.

It is therefore, possible to investigate the stability of a servo by finding the roots of the characteristic equation

$$G(s) \equiv a_n s^n + a_{n-1} s^{n-1} + a_1 s + a_0 = 0 \qquad (2)$$

[1]References are tabulated at end of article.

Performance

Part 1

Frequency response and stability

Nyquist criterion

Algebraic criteria

Response criteria

This can be very tedious if $n>3$, as it probably will be in most servos. Further on rapid methods for investigating the absolute and the relative stability of systems will be discussed.

There are certain helpful rules regarding stability based upon the transfer function,

$$\frac{\theta_o}{\theta_i}(s) = Y_c(s) = \frac{b_m s^m + \ldots + b_1 s + b_0}{a_n s^n + \ldots + a_1 s + a_0} \qquad (3)$$

of a linear servo. These rules are:

1. If $m > n$, the system is physically unrealizable.
2. If any of the a coefficients in the denominator is negative, then the system is in general unstable.
3. If a_n exists and any of other coefficients a_{n-1}, . . . , a_0 is zero, then the system is unstable.

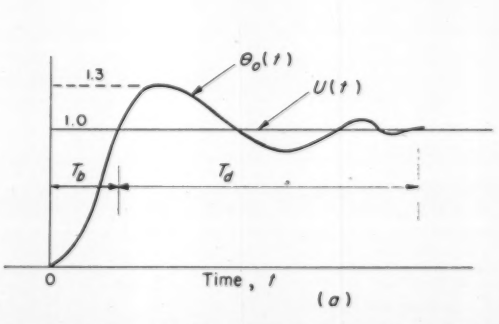
It must be realized that although these rules can reveal an unstable servo, they cannot prove that a system is stable. In other words they are not sufficient tests for stability.

Frequency Response and Stability: Suppose $s = j\Omega$ is an imaginary root of $G(s) = 0$. Then for a complex sinusoidal input of frequency ω, the transformed output is given by

$$\theta_o(s) = \frac{Y_c(s)}{s - j\omega} = \frac{F(s)}{(s-h_1)(s-h_2)\ldots(s-j\Omega)(s-j\omega)} \qquad (4)$$

So that when the input frequency ω is equal to Ω, the partial fraction expansion for $\theta_o(s)$ will contain the term, $C/(s-j\Omega)^2$. This results in the term $Cte^{j\Omega t}$ in the weighting function. This component of the response is an oscillation whose successive amplitudes increase linearly without limit. The system is therefore unstable. This phenomenon is known as resonance.

In practice, as previously stated, the output amplitude can only increase until the system fails or until some nonlinearity, such as saturation of the power source, intervenes to limit the amplitude. A self-maintained oscillation is then set up. This phenomenon, called *hunting* will only occur in practice where a closed-loop sequence monitors a power source. Self-maintained oscilla-



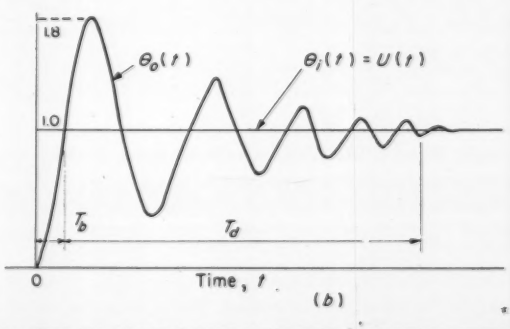


Fig. 1—A servo system with good relative stability characteristics, *a*, may be defined as one having a maximum overshoot of 0.3 and comparatively short decay time, T_d, equal to about four times the buildup time, T_b. A relatively unstable system, *b*, has overshoot of 0.8 and decay time equal to 10 times the buildup time. The relatively unstable system does, however, possess absolute stability since oscillations dieout.

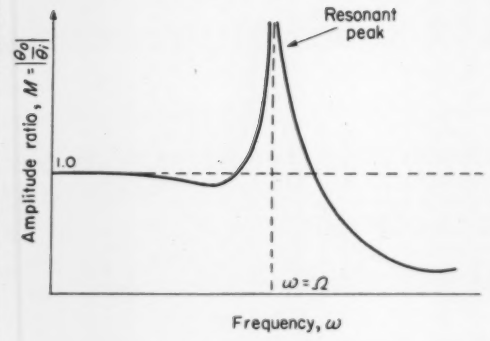


Fig. 2—Resonance in a servo system is one of the possible types of instability. If $h = j\Omega$ is an imaginary root of the denominator of the overall servo transfer function, it indicates that at some frequency, Ω, there is a resonant peak. Some component of the servo system would be overloaded and fail at this frequency as the amplitude ratio tended to infinity.

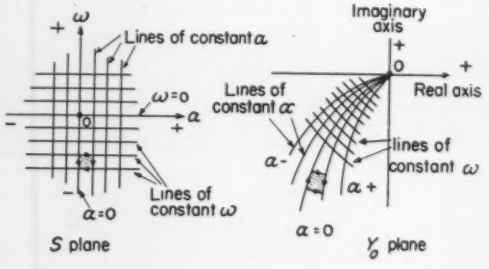


Fig. 3—Lines of constant α and ω in the s plane correspond to similar contours in the Y_o plane which depend on the function $Y_o(s)$. This is known as *conformal mapping*. The small shaded square in the s plane corresponds in the limit to the small shaded area in the Y_o plane.

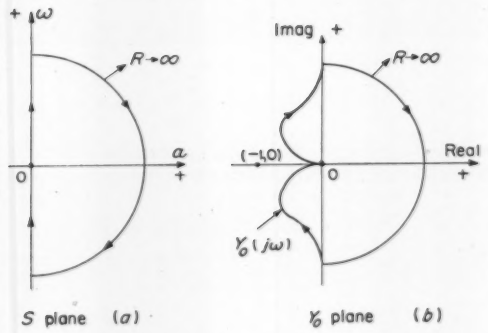


Fig. 4—The Nyquist criterion for stability is that the point $(-1,0)$ shall not fall within the shaded region in the Y_o plane obtained by conformal transformation of and corresponding to the shaded region in the s plane. The criterion holds true provided all system elements are themselves stable.

tions in other spheres (for example, aircraft flutter vibrations) can be traced to the same cause.

As established in a previous article[2], it is possible to plot $|Y_o(j\omega)|$ against frequency, ω. Thus

$$|Y_c(j\omega)| = M(\omega) = \frac{|F(j\omega)|}{\sqrt{(\omega^2 + h_1^2)(\omega^2 + h_2^2)\ldots(\omega^2 + h_n^2)}} \quad (5)$$

Therefore, if $h = j\Omega$ is an imaginary root of $G(s) = 0$, $M(\omega)$ will become infinite when $\omega = \Omega$, Fig. 2. Thus, if the overall amplitude response curve becomes infinite at any frequency, it indicates the presence of an undamped oscillation in the weighting function, and therefore instability.

A servo will also be unstable if there is a root of the form $\alpha' + j\Omega'$, where α' is positive. In this case the amplitude plot would be the same if we replaced the unstable root by $-\alpha' + j\Omega'$. This method does not give conclusive proof of stability, although as will be shown later, once absolute stability has been established, $M(\omega)$ and $\phi(\omega)$ give useful information on relative stability.

Obviously, some simple and conclusive tests for stability would be very helpful. Two approaches to this problem will be outlined. They are: (1) The Nyquist criterion and (2) algebraic criteria.

Nyquist Criterion: This utilizes the open-loop harmonic response function $Y_o(j\omega)$, and is based upon the properties of functions of a complex variable. Consider first the loop transfer function $Y_o(s)$, where in general s is a complex number of the form $s = \alpha + j\omega$. Corresponding to each value of s there is particular value of $Y_o(s)$. This can be shown by showing the value of s as a point in a complex plane called the s plane, and the corresponding value of $Y_o(s)$ as a point on another complex plane, called the Y_o plane. Corresponding to a contour in the s plane there is a contour in the Y_o plane. The shape of the latter depends on the function $Y_o(s)$, and hence on the parameters of the servo it represents.

Thus, if the s plane is divided into a net of lines of constant α and constant ω, parallel to the axes, Fig. 3, there is a corresponding pattern of lines in the Y_o plane. This is called *conformal mapping*. If $Y_o(s)$ is what is known as an analytic function, and it certainly is for the linear servos being considered, then small squares in the s plane correspond in the limit to small squares in the Y_o plane, Fig. 3. This is called a *conformal transformation*. The important point is that the squares are traversed in the same sense, as will be shown.

The point $(-1 + j0)$, written $(-1, 0)$, in the Y_o plane corresponds to a point $(\alpha_1 + j\omega_1)$ in the s plane. That is,

$$Y_o\ (\alpha_1 + j\omega_1) = -1 \qquad (6)$$

In other words $(\alpha_1 + j\omega_1)$ is a root of the characteristic equation $G(s) = 1 + Y_o(s) = 0$. For stability α_1 must be negative, or $(\alpha_1 + j\omega_1)$ must not lie in the region shown shaded in Fig. 4*a*. Corresponding to this region there is a shaded region in the Y_o plane as shown in Fig. 4*b*. Because of the previously mentioned conformal transformation, this region is bounded by the contour $Y_o(j\omega)$ and lies to the right of it as the contour is traversed from $\omega = -\infty$ through $\omega = 0$ to $\omega = +\infty$. The condition for stability is therefore that the point $(-1, 0)$ shall not lie in this shaded region of Y_o plane.

The condition stated holds if all the elements in the system are themselves stable. Very occasionally systems do contain unstable components, usually due to some local positive feedback loop around a component. This does not necessarily mean that the overall system is unstable, but in this case the condition for stability depends on how many times the contour $Y_o(j\omega)$ encircles the point $(-1, 0)$. In determining the stability of these so-called *nonminimum-phase* systems the exact form of the loop transfer function must first be obtained. However, they are sufficiently rare in mechanical servos to be neglected in this discussion. They will be discussed in a later article.

In the condition for stability just stated it would be necessary to draw the whole of the $Y_o(j\omega)$ contour, including a large circular arc. The sweep of this arc depends on the power r in the denominator of the loop transfer function (Equation 12, Ref. 2). But in practical servos it is unnecessary to go to all this complication. If the $Y_o(j\omega)$ contour from $\omega = 0$ to $\omega = +\infty$ is plotted, then the condition for stability is: *The point* $(-1, 0)$ *must always lie to the left of the contour when it is traversed in the direction of increasing* ω, Fig. 5. A contour passing through the point $(-1, 0)$ represents the critical stability boundary.

The Nyquist criterion can be given a simple physical explanation. Where $Y_o(j\omega)$ crosses the negative real axis, the output lags the error by 180 degrees. Thus any sinusoidal pulse introduced as an error passes through the loop to the output and is reintroduced as an error 180 degrees behind the initial pulse, as shown in Fig. 6*a*. The amplitude of this pulse will be $|Y_o|$ times the amplitude of the initial pulse. Thus, if $|Y_o| = 1$ at this frequency, a continuous oscillation can be maintained, since this second pulse will cause an equal and opposite one to be introduced, and so on. If $|Y_o| > 1$ at 180-degree phase lag, the oscillation will increase in amplitude, Fig. 6*b*. Obviously the desired condition for stability is $|Y_o| < 1$ at the given frequency.

In most servos stability depends on the value of the scalar gain K, where

$$Y_o\ (s) = \frac{K f(s)}{s^r g(s)} \qquad (7)$$

and $f(s)/g(s) = 1$, when $s = 0$.

That is to say there is a critical value for K

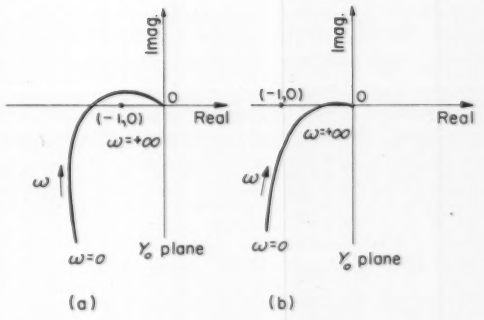


Fig. 5—Application of the Nyquist criterion for stability can be simplified in practice by plotting the Y_o $(j\omega)$ contour only from $\omega = 0$ to $\omega = \infty$. The condition for stability then becomes that the point $(-1,0)$ must always be to the left of the contour when it is traversed in the direction of increasing ω. The plot for an unstable system is shown at *a*. The contour at *b* fulfills the conditions for stability.

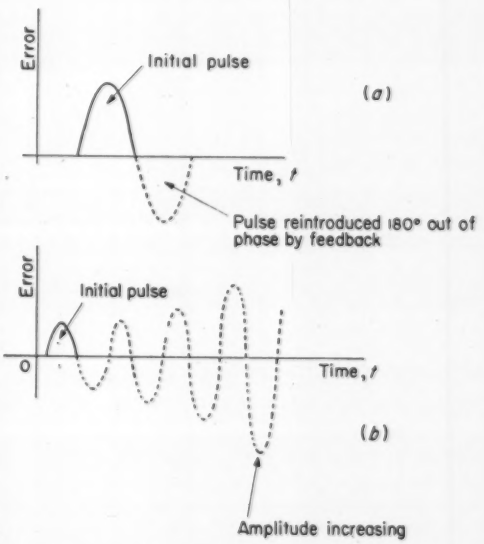


Fig. 6—If the Y_o $(j\omega)$ contour crosses the negative real axis, servo output lags the error by 180 deg. Any sinusoidal pulse introduced as an error passes through the servo loop to the output and is reintroduced as an error 180 deg behind the initial pulse, *a*. Amplitude of this pulse is $|Y_o|$ times the amplitude of the initial pulse. Therefore, if $|Y_o| = 1$, continuous oscillation will be maintained. If $|Y_o| > 1$, the oscillation will increase in amplitude, *b*. Obviously for a stable system $|Y_o|$ must be less than one. It is this condition which the Nyquist plot serves to establish.

above which the servo becomes unstable. In practice, for good relative stability, K must be set somewhat less than this critical value, as will be shown. From Equation 7 it can be seen that changing K merely alters the scale of the $Y_o(j\omega)$ contour, or *Nyquist plot* as it is frequently called.

Algebraic Criteria: These are expressed in terms of relations between the coefficients of the powers of s in the characteristic equation.

$$G(s) \equiv a_n s^n + \ldots + a_1 s + a_0 \tag{8}$$

One of these criteria is due to Hurwitz. This is as follows: Write down the determinant of order $n - 1$,

$$\Delta \equiv \begin{vmatrix} a_1 & a_0 & 0 & 0 & 0 & 0 & \ldots \\ a_3 & a_2 & a_1 & a_0 & 0 & 0 & \ldots \\ a_5 & a_4 & a_3 & a_2 & a_1 & a_0 & \ldots \\ a_7 & a_6 & \ldots & \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \end{vmatrix} \tag{9}$$

Then for stability all the a's must be of the same sign, and Δ must be positive when evaluated. For example, if

$$G(s) = a_3 s^3 + a_2 s^2 + a_1 s + a_0 \tag{10}$$

then

$$\Delta = \begin{vmatrix} a_1 & a_0 \\ a_3 & a_2 \end{vmatrix} \tag{11}$$

and the condition for stability is

$$a_1 a_2 > a_0 a_3 \tag{12}$$

As a further illustration, if

$$G(s) = a_4 s^4 + a_3 s^3 + a_2 s^2 + a_1 s + a_0 \tag{13}$$

then

$$\Delta = \begin{vmatrix} a_1 & a_0 & 0 \\ a_3 & a_2 & a_1 \\ 0 & a_4 & a_3 \end{vmatrix} \tag{14}$$

and the condition for stability is

$$a_1 (a_2 a_3 - a_1 a_4) > a_3^2 a_0 \tag{15}$$

There are other similar algebraic criteria—for example, Routh's criterion. Although they differ in method they give the same results.

The advantage of algebraic methods is that they are simple to apply and give clear-cut decisions. However, they only give the conditions for absolute stability, and do not give any data on the relative stability of the system.

On the other hand, the Nyquist criterion is sometimes difficult to use when determining absolute stability, although if correctly used it always gives the right results. The great advantage in drawing a Nyquist plot is that it can also be used to determine the relative stability and response characteristics. In practice it is a good idea to use both Nyquist and algebraic methods.

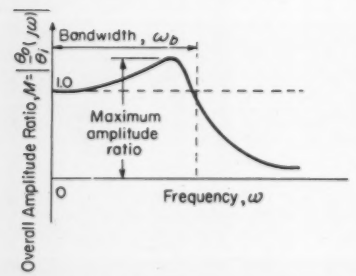


Fig. 7—Limiting the maximum value of M to 1.3 to 1.5 results in an ideal transient response characteristic without too many overshoots.

RESPONSE

With the necessary conditions for absolute stability discovered response characteristics can be evaluated. No clear-cut response criteria can be laid down since they depend on the field of application and on the types of inputs likely to be encountered. In servomechanisms (for example, remote-position-controllers), the input is likely to change continuously and rapidly, with perhaps many changes of direction per second. In general the output must have small following errors, and this means high sensitivity as well as static accuracy.

In automatic regulators (for example speed-governors), the input is likely to remain constant over long intervals of time. The output response to change in input setting must usually be accurate rather than sensitive. In fact, the control must sometimes react slowly to input change so as not to overload the system. Continuous excitation may come from some unwanted external disturbance, and it is desirable that the system

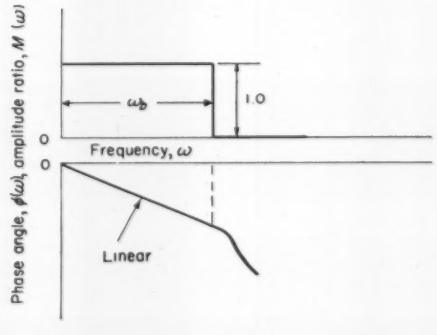


Fig. 8—With the idealized frequency response shown here, $M = 1$ over the entire bandwidth and zero at higher frequencies. The phase angle is linear throughout the bandwidth.

does not respond very much to this disturbance. In process controls, which are special forms of regulators, the time scale may be very different from that of servomechanisms. Here there may be very large time lags, especially in the plant itself.

Since inputs are so variable, the analysis presented here will be performed by considering the response to certain idealized input functions. In the preceding article[2], methods for finding the transient response to either an impulse function or a step function and the frequency response to a sinusoidal input were discussed. The choice of which method to use for design purposes is purely optional and depends ultimately on the preferences of the designer. Each method has certain advantages and disadvantages which will be briefly outlined.

The transient response method is usually based on response to the Heaviside unit step function, $U(t)$. Results are easy to interpret when plotted graphically, but they are difficult and tedious to obtain because the characteristic equation has to be solved, and then the final expression plotted in graphical form. Another big disadvantage is that if any parameter is changed or if additional elements are put into the loop, the whole process has to be reworked. It is also very difficult to associate any characteristic in the response with particular elements in the loop.

Thus, while transient response can be used to identify a good or bad system, it does not often suggest how to modify the system so as to improve its response. These faults become very much worse when the degree, n, of the characteristic equation is greater than three.

With frequency response methods, mathematical labor is shorter and simpler. Also in this direction some simple aids exist. These will be discussed in a later article. The great advantage of frequency response methods is that the effect of modifying the elements in the system, or adding new components, can be easily accounted for. The disadvantage is that the response vector curves do not give a physical picture of system behavior. That means that a set of rules must be available to correlate frequency response curves with the transient behavior of the system. No concrete set of such rules exists, unfortunately, but there are some approximate rules which will shortly be given.

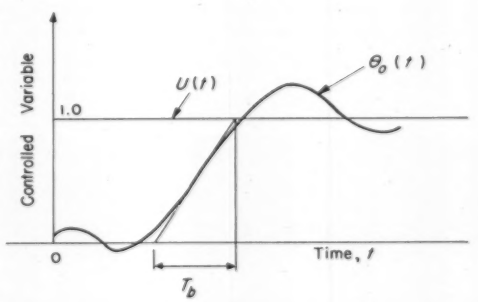


Fig. 9—The response of a system with the characteristics shown in Fig. 8 to a step function, $U(t)$, illustrates the relationship between bandwidth and buildup time. Response of such a system is much as desired; however, the system is physically unrealizable since response is so small at $t = 0$.

Successful use of either of these design techniques, therefore, depends largely on the skill of the engineer. Only with experience can he weigh the value of any design criteria.

In practice it is convenient to do the initial design work using frequency response methods. Once the design has been more or less finalized in this way, then a check can be made by plotting its transient response.

Response Criteria: Based on transient response to the unit step function, $U(t)$, response of a stable system will in general involve an overshoot, followed by a decaying oscillation. The response is generally considered satisfactory if the maximum overshoot is about 30 per cent of the step, with only two or three large overswings following it. Fig. 1*a*. Less than 10 per cent overshoot is sometimes necessary.

Decay of the oscillations depends on the values of the roots, $(-\alpha + j\Omega)$, of the characteristic equation. All oscillations will have substantially disappeared at time $t_d = 4/\alpha_m$, where α_m is the magnitude of the smallest real component of all the roots. The number of oscillations depends on the ratio α/Ω for each of the roots. A value of about 0.5 is usually quoted as satisfactory for this ratio.

A measure of sensitivity is given by the build-up time T_b. This has been variously defined as:

1. Time to pass through 1.0 for first time.
2. Time to get within a steady 2 per cent of 1.0.
3. Time to swing through 1.0 at maximum rate of response.

Based on the overall response function $Y_c(j\omega)$, the requirement for no steady-state positional error is that $M = 1$ when $\omega = 0$, or that $a_0 = b_0$, where

$$Y_c(j\omega) \equiv Me^{j\phi} = \frac{b_0 + b_1 j\omega + \ldots + b_m (j\omega)^m}{a_0 + a_1 j\omega + \ldots + a_n (j\omega)^n} \qquad (16)$$

In practical servos $n > m$, so that $M \to 0$ and ϕ is negative as $\omega \to \infty$. Thus a typical response is of the form shown in Fig. 7.

The amplitude or $M(\omega)$ curve is very informative. High resonant peaks correspond to lightly damped roots in the characteristic equation; that is, α/Ω is about 0.2 or less. An ideal type of characteristic is shown in Fig. 7. If the maximum value of M is limited to 1.3 or 1.5, then in gen-

Nomenclature

a, b = Constants
j = Square root of minus one (symbolic)
K = Scalar gain constant
r = Order of servo
s = Laplace operator
T_b = Buildup time
T_d = Decay time
t = Time variable
$U(t)$ = Unit step function
$W(t)$ = Weighting function
$Y_c(s)$ = Overall servo transfer function $= F(s)/G(s)$
$Y_o(s)$ = Loop transfer function
ω = Angular frequency, rad per sec
ω_b = Bandwidth of amplitude response

eral a good transient response is obtained without too many overshoots.

Sensitivity is determined by the bandwidth ω_b. This is variously defined as:

1. $M(\omega_b) = 1.0$ beyond resonant peak, if response is of type shown in Fig. 7.
2. $\int_0^\infty \frac{M^2\, d\omega}{\omega_b} = 1.0$ holds for curve with no resonant peaks.
3. $M(\omega_b) = 1/2$ beyond any resonant peak.

Since both relate to sensitivity a relationship between the bandwidth ω_b and the build-up time T_b might be expected. There is an approximate relationship between the two, but generally nothing more can be said except that increasing the bandwidth reduces the build-up time and hence improves the sensitivity of the servomechanism. An approximate relationship between the two can be established if an idealized frequency response, Fig. 8, is considered. Here $M = 1$ up to the bandwidth frequency ω_b, and is zero for all higher frequencies, while the phase angle is linear in bandwidth. The response of a system, having such a characteristic, to a step function is shown in Fig. 9. This response has a small value when $t = 0$, so the system is not physically realizable. Apart from this, its response is very much as desired.

Using the third of the definitions of T_b previously given, it can be shown that

$$T_b = \frac{\pi}{\omega_b} \qquad (17)$$

This supports the previous remarks on increasing the bandwidth. Generally to increase ω_b to achieve a more rapid response *the scalar gain constant K must be as large as possible.* However, as is shown by the Nyquist criterion, this can lead to instability, and almost invariably means a more oscillatory response. Therefore, a compromise value for K must be achieved. One of the fundamental problems of servo design is to get the maximum possible bandwidth for a given scalar gain K.

REFERENCES

This article is the third in a co-ordinated group by J. M. Nightingale on servo systems. Previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" .....May 17, 1956
2. "Servo Mathematics" .....June 28, 1956

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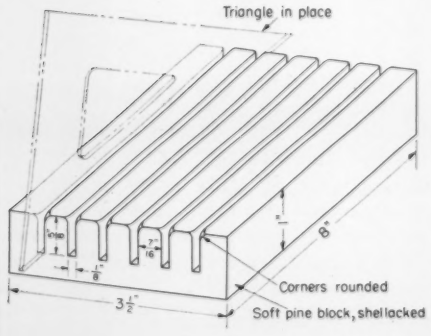
Tips and Techniques

Drawing Implement Holder

Triangles, pencils, protractors and other drawing implements may be kept conveniently at hand in this easily constructed holder. Larger implements should be kept in the central slots, smaller items such as pencils in the end slots. Rounding of the corners of the slots facilitates replacement of used pieces. Dimensions may, of course, be altered to suit the user.—W. D. RENIERT, *Sheridan Machine Co., Easton, Pa.*



Sample Plate for Screws

Make a sample plate for quick identification of screws and nuts. Drill a strip of 1/16-in. thick brass or steel with clearance holes for the range of screw sizes used in your work. Obtain one sample of each size screw and nut, and assemble to the plate. — ELMER CERNY, *Chicago, Ill.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Aluminum Die Castings Used Extensively in Outboard Engines

LIGHT weight, compactness and high power are achieved in the design of a recently introduced line of outboard engines by extensive use of aluminum die castings. Additional advantages derived from the use of aluminum are corrosion resistance and good heat-dissipating properties.

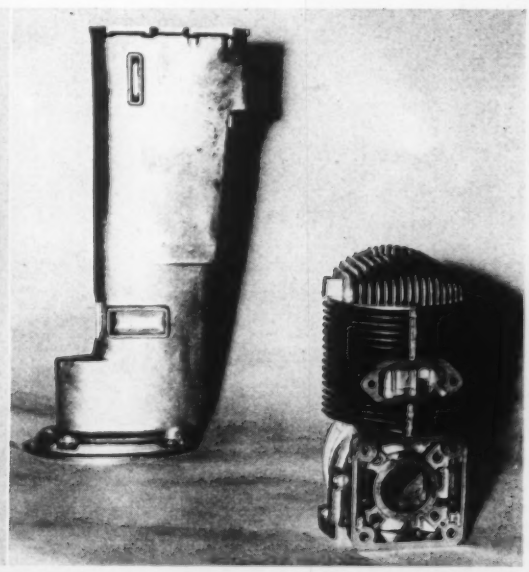
Largest engine in the line produced by West Bend Aluminum Co. develops 25 hp and weighs but 118 lb. Pushbutton starting and remote control by push-pull cable are incorporated in this particular model. Another interesting feature is the use of a one-piece molded glass-fiber engine cover.

Die castings, made by Precision Castings Co. Inc., include such large pieces as the swivel bracket, drive-shaft casing, and steering handle. The 19-in. long steering handle is made in a one-impression die which, with a stationary core in the ejector half, forms the complicated boss on the large end. A side core produces the mounting hole.

Drive shaft casing is 15-1/16 in. long. A split core, pulled hydraulically from each end, is used to form internal contours. The various holes are also cored. Draft on the inside surface of this piece is held to 1 degree per in.

Swivel brackets weigh about 4 lb and measure 10 by 7 in. Split, removable and angular cores are used to produce this highly stressed piece.

Perhaps the most intricate and interesting of these die castings is the cylinder block. Using one die set and interchangeable cores, four different cylinder bore sizes and four different crankcase openings can be cast for use on engines of different power ratings. A steel bushing may also be used as a cylinder bore insert in the same master die.



CONTEMPORARY DESIGN

Welding Composite Steels:

APPLIED LINERS

By Helmut Thielsch
Metallurgical Engineer
Grinnell Co. Inc.
Providence, R. I.

APPLIED liners are composite plates generally consisting of a relatively thin sheet of a corrosion-resisting metal bonded *intermittently* by welding to a backing steel. The backing steel is usually a commercial grade of mild or low-alloy steel.

Like clad steels—another kind of composite steel treated in MACHINE DESIGN, May 3, 1956—applied liners combine the desirable properties of a lining alloy with the strength of the backing material.

Applied liners are either assembled as plates prior to being formed into special shapes, or the separate backing plate and liner plate are preformed into the final shapes desired and subsequently joined together during fabrication or assembly of the vessel.

Spot or seam welding are used where the applied liners are produced as plates first. Arc-welding techniques are generally employed when preformed liners are attached to preformed vessels or vessel parts.

Lining by Spot or Seam Welding

In lining plates, the liner sheet material is placed on the backing steel plate and is welded to it by spot or seam welding in special resistance-welding equipment, Fig. 1. In spot welding, which is the most commonly used method, the spacing

Fig. 1—Typical set-up for spot welding.

Applied liners can be used to obtain corrosion resistance inexpensively in large vessels and structures. This article summarizes the methods of welding the liners to backing steels and joining the composite plates.

Fig. 2—Above—Dished head formed out of seam welded applied liner plate.

between the spot welds may be specified between 1 by 1 in. and 3 by 3 in. The closer spacings generally are desired for high-temperature applications. A 1½ by 1½ in. spacing between spot centers in either direction would provide a bond attachment of about 18 per cent, which is considered adequate for most operations.

Where seam welding is used, the welds are overlapped in the longitudinal direction and may provide a weld attachment as high as 75 per cent, Fig. 2. Seam-welded liner plates are made by bonding one or several liner sheets to the backing steel plate.

When spot or seam-welded composite plates are to be hot formed by rolling, pressing, spinning or other procedures, a seal weld should be deposited around the edges of each composite sheet. Properly made seal welds will help to prevent warping along the edges during heating and hot forming, and minimize oxidation and scaling of the unfused portion of the "surfaces" on the inside of the composite plate.

In general, the forming operations on spot or seam welded composite plates are similar to those used with integrally clad plates.

The final assembly of the preformed or preshaped composite plates should be done with the same procedures, bevel preparations, and welding materials as recommended for clad steels, see MACHINE DESIGN, May 3, 1956, page 96.

Fig. 3—Below—Plug welding of vessel section.

Lining by Arc Welding

Lining by arc welding methods is generally done by constructing the whole or part of the vessel or structure out of the mild or low-alloy backing steel. The alloy liner panels usually are shaped and preformed to fit the shape and contours of the prefabricated vessel or structure. They are subsequently attached by welding to the backing steel. Where the contours of a vessel have a gradual curvature, flat liner panels may also be brought into tight contact with the backing steel by means of pressing and tacking procedures.

The most widely used lining methods are *plug*

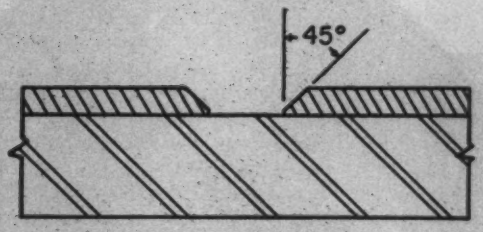


Fig. 4 — Bevel preparation for liners over ⅛-in.

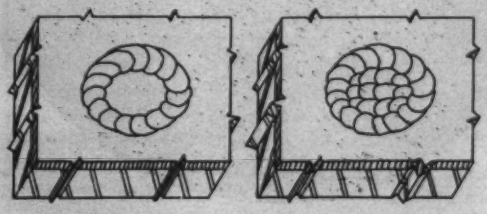


Fig. 5—Ring welding procedure recommended for plug welding by manual shielded metal-arc process.

welding, *strip* welding and *through* welding.

Plug Welding: In plug welding, the lining is attached by welding each liner panel to the backing steel through holes punched or drilled through the liner panel material, Fig 3. Ordinarily, in vessel fabrication, the size of the liner panel varies from 2 to 3 ft wide to 5 to 10 ft long. Holes are ½ to 1 in. diameter. Diameters of less than ½-in. can cause welding difficulties by shorting out the welding arc, resulting in excessive porosity or slag entrapment and in poor bonding. Where the liner panel thickness exceeds ⅛-in., the edges of the holes are occasionally beveled, Fig. 4.

Center-to-center distance between the holes should depend primarily upon the service conditions. The distance should be decreased for applications involving thermal cycling or temperature gradients. The values in Table 1 are frequently used as a guide.

In vessels operating under vacuum, a center-to-center distance of 3 to 4 in. is frequently recommended. For room-temperature service not involving thermal or mechanical fatigue, center-to-center spacings of as much as 12 in. have been found acceptable.

Shielded metal-arc welding is ordinarily used. However, the semiautomatic submerged-arc and inert-gas consumable metal-arc processes have also been successfully used. The former is restricted primarily to flat and horizontal welding. The latter is suitable for all-position welding.

After the panel sections have been placed in position and pressed against the backing steel at their centers, a tack weld should be made through one of the center holes by depositing a weld bead across the bottom of the hole. Additional tack welds should be deposited every third to fifth hole by gradually progressing outward from the initial center tack weld. The edges of the liner panel should be tack welded to the backing steel with approximately 1 in. long welds about 5 to 10 in. apart.

The final plug welding is usually done by following a so-called "ring" welding procedure, Fig. 5, consisting of depositing a seal weld around the inner edge of the hole for fastening the liner, followed by "filling in" the center space.

Strip Welding: In strip welding the liner is attached to the backing steel by means of welds attaching adjacent sheets to each other and to the backing steel, Fig. 6.

Length of the strips usually varies from 2 to 3 ft for field-applied liners and from 2 to 10 ft for shop-applied liners. Width of the strips may vary between 2 and 6 in., depending upon the service requirements. The values in Table 2 are frequently used as a guide.

Narrower strips should be used when the service involves severe thermal cycling or steep temperature gradients. On the other hand, strips of widths of as much as 24 in. have been used for essential noncritical service applications at room temperature.

In cylindrical vessels, the strips are usually applied perpendicular to the longitudinal axis of the vessel. On conical shapes, parallel arrangements are preferred, Fig. 7. Dished heads are lined either with parallel or herringbone arrangements, the

Table 1—Hole Center Distances for Plug Welded Liners

Maximum Operating Temperature (F)	Center-to-Center Distance Between Holes (in.)
up to 450	4–6
450–750	4
750–850	3½
850–950	3
over 950	2½

Table 2—Strip Widths for Strip-Welded Liners

Maximum Operating Temperature (F)	Maximum Strip Widths of Stainless Steels	
	Type 400 Series (in.)	Type 300 Series (in.)
up to 450	up to 6	up to 6
450–750	4½–5	3–4
750–850	4	2½–3
850–950	3½	2
over 950	3	2

latter being frequently preferred since it reduces the tendency for welders to lap or shingle the strips.

Typical strip lining methods are illustrated in Fig. 8. The "three bead" fillet butt-welding procedure, Fig. 8*a*, is generally preferred. Possible undesirable effects which may be the result of weld-metal dilution* usually are prevented by the use of a higher alloyed electrode. An example is the use of 25 Cr, 20 Ni stainless-steel electrode for welding 18 Cr, 8 Ni stainless-steel liners.

Three "lapping"' methods are also occasionally used, particularly where undesirable weld-metal dilution cannot be avoided by means of electrodes more highly alloyed than the liner alloy. Fit-up also is not as much a problem with these lapping methods. However, the lapping methods are more costly than the fillet-butt-welding procedure shown in Fig. 8*a*. For example, in the butt-strap method, Fig. 8*c*, four weld deposits are required for each joint. The lap welds on liner panels with formed edges in Fig. 8*b* require special forming operations. The lapping methods also require a larger quantity of stainless steel. Other objections are that the ridge effect in "lapped" linings makes cleaning more difficult; that welds covered by lapped linings cannot be inspected; and that lapped linings will not withstand as high a hydrostatic force tending to pull them loose from the base plate as plug-welded or fillet-butt-welded liners.

*Dilution describes the mixing of the molten welding filler metal being deposited with that portion of the base metal which is melted (fused) by the welding operation.

Through Welding: In through welding the liner panel is attached by depositing a submerged-arc weld along the edge of each panel and also a series of submerged-arc welds through the liner panels by fusing "through" the liner and penetrating into the base steel, Fig. 9. Panels 1½ to 2 ft wide by 3 to 4 ft long represent typical sizes.

Prior to submerged-arc welding these preformed panels have to be carefully held in place with suitable jacks and tack welds. By some fabricators this tacking is done by manually submerged-arc

Fig. 6—Strip welding of vessel.

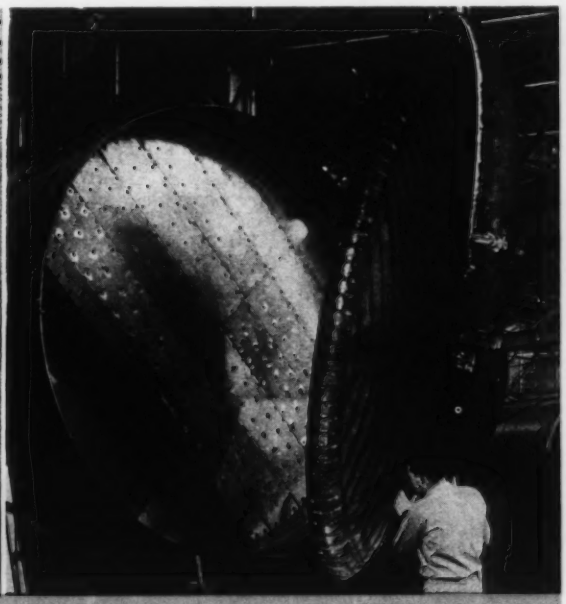


Fig. 7—Vessel head strip lined by metal-arc welding prior to attachment to vessel.

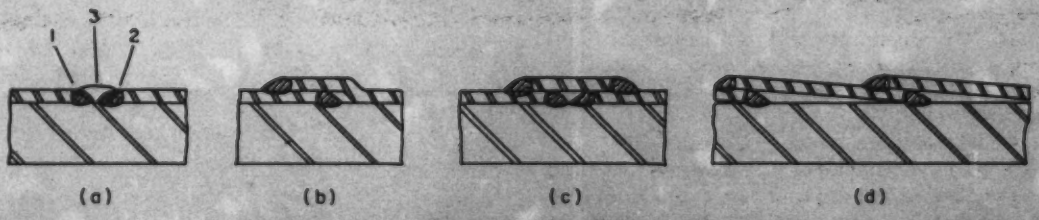


Fig. 8—Principal strip lining methods: *a*, fillet-butt; *b*, cap or joggle; *c*, butt-strap; and *d*, shingle.

Table 3—Electrode and Welding-Rod Compositions for Welding Liner Panels to Backing Steels

Liner Material	Weld-Metal Dilution Is Involved§ First Pass and "Through" Welding	Weld-Metal Dilution Is Not Involved§
302	E310, E309	E310, E309, E308
304	E310, E309	E310, E309, E308
304L*	E310 Cb, E309 Cb	E310 Cb, E309 Cb, E347, E308L*
309	E310	E310, E309
310	E310	E310
316	E310 Mo, E309 Mo	E310 Mo, E309 Mo, E316
316L*	E310 Mo	E316L*, E318
317	E310 Mo	E317
321	E310 Cb, E309 Cb	E310 Cb, E309 Cb, E347
347	E310 Cb, E309 Cb	E310 Cb, E309 Cb, E347
405	E310, E309, E430†	E310, E309, E430†
410	E310, E309, E430†	E310, E309, E430†
430	E310, E309, E430†	E310, E309, E430†
Nickel	Nickel (No. 141)	Nickel (No. 141)
L-nickel	Nickel (No. 141)	Nickel (No. 141)
Monel	Monel (No. 140)	Monel (No. 140)

*The letter L, as recently adopted by the American Iron & Steel Institute, denotes the extra-low-carbon (0.3% max C) grades.
†Must be used under certain corrosive conditions and may require special preheat- and postheat-treatments.
§For stainless steel electrode and welding rod classification see MACHINE DESIGN, Dec. 1955, page 196, Table 1. The prefix E signifies covered electrodes specified by AWS 5.4-55T and ASTM A298-55T. Where bare electrodes or welding rods are used the prefix ER applies as specified by AWS 5.9-53T and ASTM A371-53T.

welding plug welds at a center-to-center distance of about 8 in., Fig. 10.

The subsequently made "through" welds are usually spaced about 3 to 5 in. apart. Good bonding is obtained with a penetration of about 1/16-in. which represents common practice. Because of dilution by the backing steel, it is desirable to use more highly alloyed electrodes, as mentioned earlier.

Design Aspects: When existing vessels are to be lined in a shop or in the field detailed drawings should be carefully made of the liner panels which are to be fabricated and fitted into the existing structure. In case of newly fabricated vessels the detail drawings for the liner panels may be made from drawings of the existing shell. However, when old vessels which have been in service are to be lined, it is usually advisable to base the detailed drawings upon actual measurements, since the service conditions may have changed some of the original dimensions.

Attention should be given also to (1) the size of the liner panels required in vessels, heads, etc., (2) the size and spacing of the holes (when plug welding is used), and (3) panel details around openings, baffles, traps, fittings, etc.

Fig. 9 — Submerged - arc "through" welding of vessel

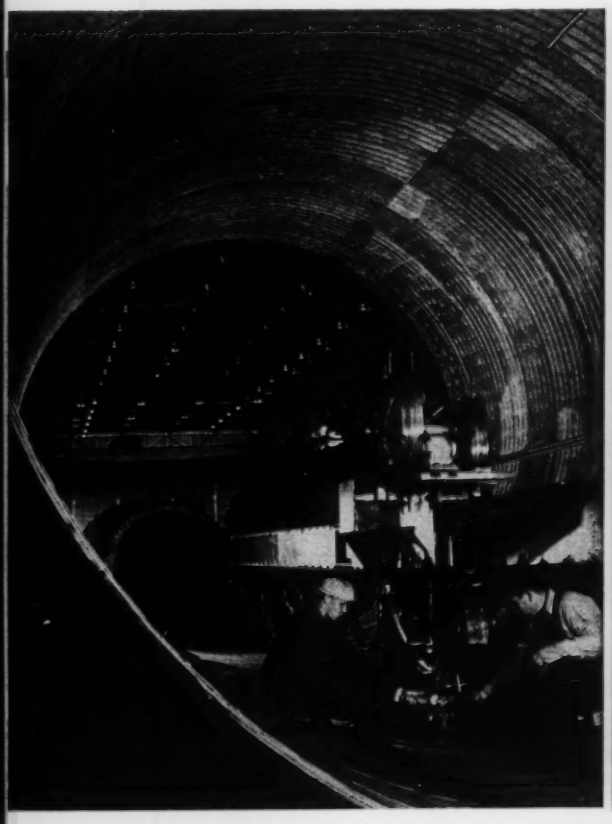


Fig. 10—Plug "tack" welding stainless-steel sheets by submerged-arc welding prior to through-welding.

Generally the liner panels are first cut out and shaped. However, where old vessels are involved which are somewhat irregular in shape and can be lined in a shop, it may at times be more convenient to delay cutting and shaping until the actual assembly and welding time.

Preforming of the liner panels is advisable where the surface contours to be lined are irregularly shaped. However, where the contour is uniformly curved as in large-diameter tanks, it frequently may not be necessary to preform (roll) the liner panels. Instead, they may be pressed uniformly and tightly against the inner surface of the vessel by jacking arrangements.

Prior to lining, the fabricated vessel must be thoroughly cleaned, preferably by sand or shot blasting.

Each preformed and preshaped liner panel must be carefully laid out, held tight against the backing steel and tack welded. For holding the panels against the backing steel, hydraulic jacking or "spider" arrangements are generally used.

Weld-Metal Overlays: At locations in lined vessels where, because of inaccessibility it would not be practical to apply liner panels, it may frequently be more convenient to apply weld metal overlays. Thus, at pipe inlets, manhole openings, etc., the exposed backing steel surfaces can be protected by weld metal overlays with welding rod alloys of proper composition. Naturally the effects of dilution must be considered in the selection of the proper filler metal alloy.

Electrode and Welding Rod Selection: In Table 3 are listed the electrode and welding-rod compositions ordinarily recommended for welding the more commonly used stainless-steel lining materials to mild or low-alloy backing steels.

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This article is the eighth in a co-ordinated group by Helmut Thielsch on welding and weldments. Previous articles, and the issues of MACHINE DESIGN in which they appeared, are:

Wrought Carbon and Alloy Steel: Weldability ..... May, 1955
Weldability of Stainless Steel ..... June, 1955
Weldability of Cast Steels ..... July, 1955
Selecting Electrodes and Welding Rods:
Part 1—Mild and Low-Alloy Steels ..... Sept., 1955
Part 2—Stainless Steels ..... Dec., 1955
Designing Welded Joints For Dissimilar Steels ..... Apr. 5, 1956
Welding Composite Steels:
Part 1—Clad Steels ..... May 3, 1956

FIGURE CREDITS

A. O. Smith Corp., Milwaukee, Wis. ..... Fig. 1
Babcock & Wilcox Corp., New York, N. Y. ..... Fig. 2
C. F. Braun & Co., Alhambra, Calif. ..... Figs. 7, 9, 10
Welding Handbook, American Welding Society, New York, N. Y. ..... Figs. 3, 6

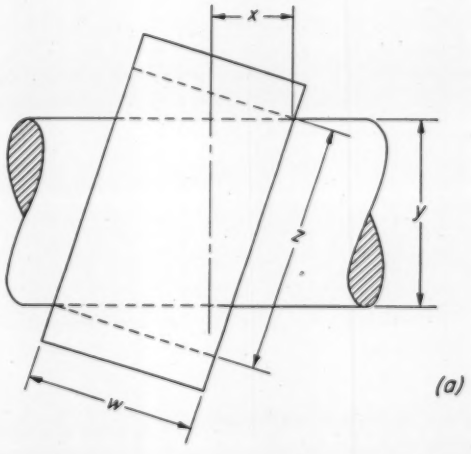
Tips and Techniques

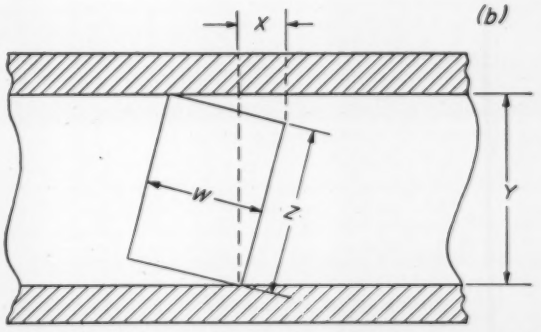
Determining Out of Squareness

AMOUNT of cocking of a ring fitted on a cylindrical shaft, sketch *a*, may be determined from

$$x = \pm \frac{z^2}{w^2 + z^2} \left(\sqrt{z^2 + w^2 - y^2} - \frac{wy}{z} \right)$$

where w = length of engagement; x = full indicator reading value of "out of squareness"; y = shaft diameter; and z = inside diameter of the ring. For the external ring, sketch *a*, the plus





sign is used; for the internal plug, sketch *b*, the minus sign. This check is especially valuable in determining proper design of plug gages and proper fits of cylindrical parts on a cylindrical shaft.—G. SEIDEN, *Air Associates Inc., Teterboro, N. J.*

Pointer

A useful pointer can be easily made by cutting approximately 3 in. from the small end of a common penholder and forcing the eye end of an ordinary sewing needle into the wood. Such a pointer can be very useful in locating measured points on a drawing and offers greater accuracy than a pencil point. The small hole in the drawing paper will not reproduce on a blueprint.—HUBERT M. PUGH, *North Judson, Ind.*

Selecting and applying

Wiring, Cables and

Design for wiring and cables must satisfy the functions of power and signal distribution and routing in electronic equipment. However, maintainability of wiring and cables within and between equipment units should not be overlooked. Basic design tips are presented in this article, fourth of a group, that will materially improve equipment maintainability.

By John D. Folley Jr. and James W. Altman
Research Scientists
American Institute for Research
Pittsburgh

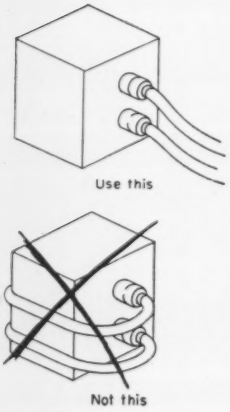


Fig. 1—Cables should be routed to avoid sharp bending when connected or disconnected.

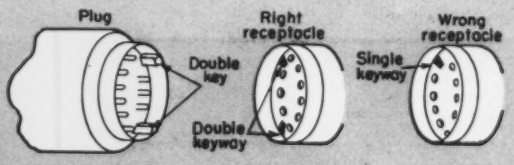


Fig. 2—Plug designed with double aligning keys to prevent wrong connections.

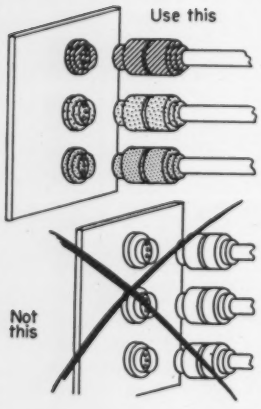


Fig. 3—Color code plugs to prevent wrong connections if like connectors are close to each other.

SINCE the purpose of interconnecting conductors is to transmit power and signals to and from the various components of electronic equipment, the conductors must make physical connection to the components. In order that transmission may continue unimpaired by moisture, vibration, fungus growth, etc., conductors are usually carefully covered with an insulating and environment-resistant covering. End connections are soldered, tightly screwed, or otherwise made semipermanent.

Such practices are intended to increase the reliability of the system by assuring that connections will not be broken or transmission degraded by extraneous environmental influence. However, these design practices may also make it more difficult for the technician to trace signals or connect and disconnect components with which he works.

Of course, this is not a design situation in which compromise is the general order; reliability should

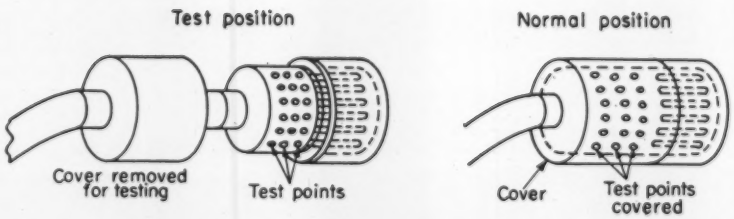


Fig. 4—Plug with accessible built-in test points and cover.

Connectors

not be sacrificed for easy maintenance. Rather, the designer should strive for maintainability design of interconnecting conductors that does not have a detrimental effect on reliability of equipment. The specific suggestions that follow, both for the conductors and for their connectors, are intended to help the designer achieve this goal.

Wires and Cables: In the design of electronic equipment, cables should be long enough to permit:

1. Each functioning unit to be checked in a convenient place. Extension cables should be provided where this is not feasible.
2. Units in drawers and slide-out racks to be pulled out without breaking electrical connections.
3. Connectors to be reached easily for replacement or repair.
4. Units that are difficult to connect when mounted to be moved to a more convenient position for connecting and disconnecting their cables.

Length of cables should be the same for each installation of a given basic type of electronic equipment if circuit functioning may be significantly affected by differences in cable length. Even if adjustment of components can compensate for cable-length variations, the use of different cable lengths in various installations may make bench adjustments inaccurate for a given installation. An adjustment that is correct for the bench mock-up may cause an installed equipment to go out of tolerance if a different cable length is used.

Cable harnesses should be designed to allow installation as a unit.

Cables should be "fanned out" in junction boxes for checking if no other test points are provided to give the same information. This arrangement requires that each check point be accessible for test probes and be clearly labeled. It also requires that maintenance instructions and diagrams indicate the use of these points and their physical and functional location.

Cable Routing: In the original design, route cables so that:

1. They cannot be pinched by doors, lids, etc.
2. They are very unlikely to be walked on or used for handholds.
3. They are accessible to the technician, that is, not located under floorboards or behind panels or components that are difficult to remove. This is particularly important for waveguides and high-frequency or insulated high-voltage cables.
4. They need not be bent and unbent sharply when connected or disconnected, Fig. 1.

Provide guards or other protection for easily damaged conductors, such as waveguides, high-frequency cable, or insulated high-voltage cables.

Identification of Connectors: Select plugs that are impossible to insert in the wrong receptacle. This requirement may be met by selecting different sizes for nearby plugs. Different keys or aligning pins, Fig. 2, on nearby plugs also will prevent wrong connections.

Plugs and receptacles should have painted stripes, arrows, or other indications to show proper position of keys or aligning pins for proper insertion position.

Each pin on each plug should be clearly identified.

Code each plug to the receptacle to which it is to be attached. Color coding may be a convenient method of coding as depicted in Fig. 3.

Test Points on Connectors: Plugs should permit access to each replaceable unit input and output not provided with a special test point. If dust or moisture is a problem, plugs with test points may be constructed with a built-in cover, Fig. 4.

If it is not practical to provide test points in plugs, adapters with test points, such as shown

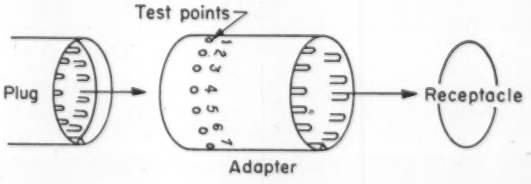


Fig. 5—Adapter designed with test points for inserting on a plug that does not have accessible test points.

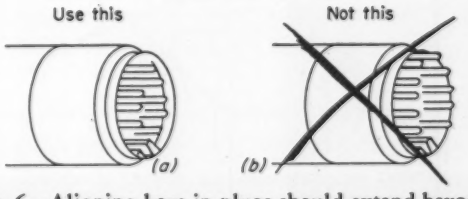


Fig. 6—Aligning keys in plugs should extend beyond the electrical pins, *a*. Electrical pins may be damaged with a design shown in *b* through poor alignment with the receptacle or through twisting a partially inserted plug.

in Fig. 5, should be supplied for insertion between plug and receptacle.

Provisions for Connecting and Disconnecting: Plugs requiring no more than one turn or other types of quick-disconnect plugs, are preferable to plugs with fine screw threads that require many turns.

Use plugs designed with a self-locking safety catch whenever feasible rather than plugs that must be safety wired.

Plugs that need safety wiring should have provision for such wiring, for instance, holes and hooks. Sometimes, these provisions are omitted.

It is easier to connect and disconnect units having a few cables with many-pronged plugs than units having many cables with too-few prongs.

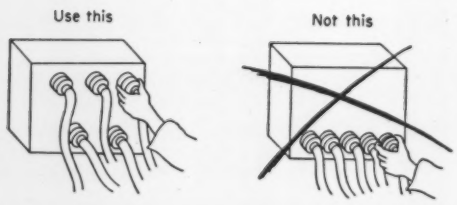


Fig. 7—Provide enough space between connectors to permit a firm grip for connecting and disconnecting.

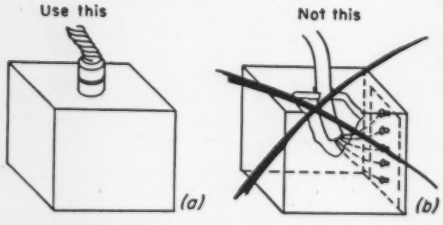


Fig. 8—Cables connected to electronic equipment through plugs and receptacles, *a*, are perferable to those "pig-tailed" to units, *b*.

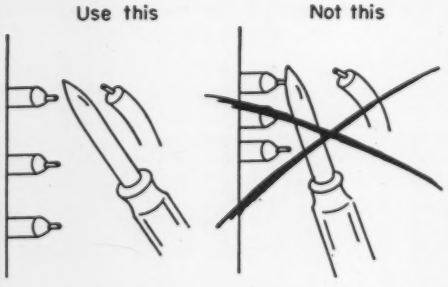


Fig. 9—Locate leads or terminals far enough apart to avoid damaging neighboring leads or other components during repair work.

It takes about the same amount of time to connect a plug with many prongs as it does to connect a plug with a few prongs.

Aligning pins or keys in plugs should extend beyond electrical pins, Fig. 6. The design in Fig. 6*a* protects the electrical pins from damage by preventing poor alignment with the receptacle or twisting of the plug when partially inserted, whereas the plug shown in Fig. 6*b* does not.

Avoid symmetrical arrangements of aligning pins or keys. Symmetrical designs permit a plug to be inserted 180 degrees from the correct position.

Design of connectors should prevent electrical contacts from being shorted by external objects.

Connectors should be located far enough apart to permit a firm hold for connecting and disconnecting, Fig. 7. The space required will depend on the size of the plugs, but a minimum distance of 2.5 in. between plugs is recommended.

When a certain portion of a machine is removable for maintenance, for example, the tail section of an airplane, cables connecting the removable portion from the rest of the machine should have a plug and a receptacle that will disconnect before the cables break. Particularly, if nonelectronics maintenance personnel do the removing, plugs may not be disconnected until considerable strain has been placed on the cabling. A jerk-open plug will part before damage is done to the cabling. A screw plug probably will not.

Whenever practicable, design the system so that receptacles are "hot" and plugs are "cold" when disconnected.

Provide plugs and receptacles for connecting cables to equipment units. When cables are "pigtailed" to units, the units are somewhat more difficult to replace, Fig. 8; obviously, damaged cables are quite difficult to replace.

Wire Connections: Plug-in contacts are usually the easiest to connect and disconnect, whereas, screw terminals offer average difficulties, and solder connections are the most difficult. From the standpoint of easy maintenance, the more easily connected and disconnected types should be used whenever practical.

The end of a wire soldered to a terminal should be left out of the solder to simplify removing it. Terminals to which wires are to be soldered should be far enough apart so work on one does not damage neighboring wires or other components, Fig. 9.

Terminals or other connections to which wires are to be soldered should be long enough to prevent burning insulation and other surrounding materials by a hot soldering iron.

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This article is the fourth in a co-ordinated series by John D. Folley Jr. and James W. Altman. Previous articles, and issues of MACHINE DESIGN in which they appeared are:

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Units, Assemblies and Subassemblies ..... June 28, 1956
Covers and Cases ..... July 12, 1956

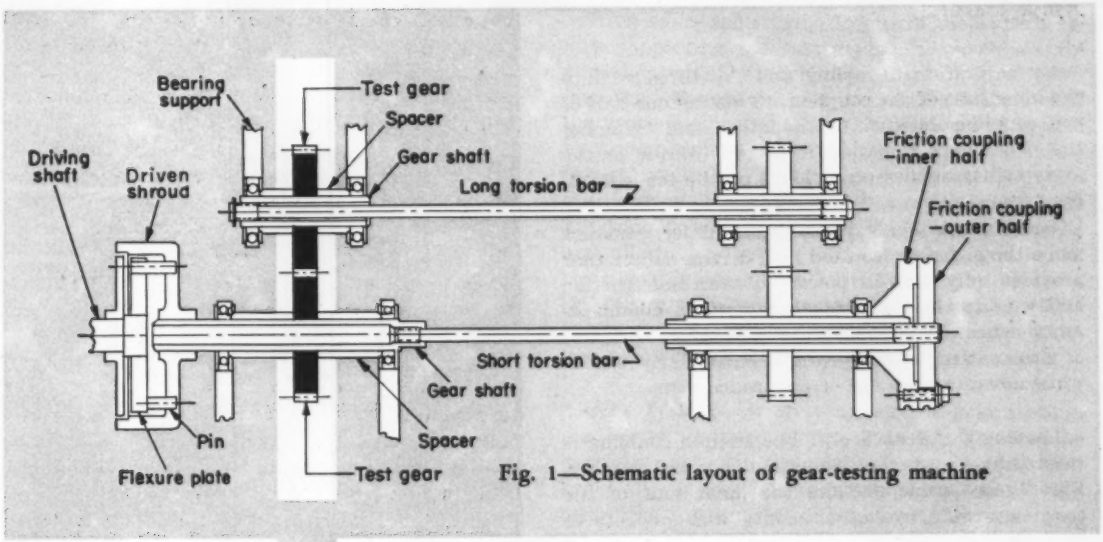


Fig. 1—Schematic layout of gear-testing machine

Design features of a practical machine for **Testing Gears**

By Herbert H. Alvord and Keith W. Hall
Mechanical Engineering Dept.
University of Michigan
Ann Arbor, Mich.

TO HELP evaluate molded Zytel 101 as a gear material, five identical test machines were designed and built by the Engineering Research Institute of the University of Michigan. The basic principle employed in these machines is not new. The construction of the machines is quite unusual, however, and several unique features have been incorporated to make them into useful research instruments.

Principle of Operation: The main function of the machines is to test gears under various conditions of load and speed to determine wear rates, fatigue life, friction losses in the teeth, and the effects of several variables upon these properties. Each machine tests two pairs of gears at one time, with one pair loaded against the other pair by applying a twisting couple to the shafts joining the gears. This is known as "back-to-back" or "4-square" testing and is commonly employed for gear work.

A schematic layout of the machine is shown in Fig. 1. Each gear is mounted on a splined hollow shaft supported in ball bearings from a common cast-iron base. The hollow shafts are connected by steel torsion bars. The twisting couple that loads the gear teeth is applied through the friction coupling at the right end. One half of this coupling is splined to the hollow gear shaft, while the other half is splined to the torsion bar. The two halves of the friction coupling are held together by four equally spaced clamping screws that extend through circular slots in the

This article is based on research data conducted for the Engineering Research Institute, University of Michigan, by contract with E. I. du Pont de Nemours and Co.

outer half of the coupling and are threaded into the inner half of the coupling. Twisting one half of the coupling relative to the other and clamping the two halves together, imparts a torque to the system that applies equal loads on the teeth of all four gears.

These tooth loads remain essentially constant while the gears are rotated by a driving motor that provides only enough power to overcome friction and windage losses. This characteristic eliminates any need to develop, absorb and dissipate the power transmitted by the gears, a particularly worthwhile advantage on life or endurance tests.

Loading the Gear Teeth: The friction coupling is twisted by a system of cables, pulleys, and weights, Fig. 2. One cable anchors the inner half of the coupling, while two other cables with buckets of lead shot attached to their ends twist the outer half of the coupling. This rather elaborate loading system is used to eliminate bending from those parts that support the two halves of the coupling. The cables are fastened to the coupling with small screws threaded radially into the coupling. After the coupling halves have been clamped together, the cables and their fastening screws are removed to permit rotation.

To prevent bending, the same weight of lead shot is placed in each bucket. Thus, the torque exerted on the gears is the product of the weight of one bucket and the diameter of the friction coupling. Any desired torque can be obtained by varying the weight of shot in the buckets.

Capacity of Machine: Gears having pitch diameters of from 1 to 4 inches can be accommodated by moving the bearing supports to obtain the proper center distance. The four bearing supports of the rear, or right-hand, gears of Fig. 2 are movable as a unit, while the other supports are integral with the base.

Torsion bars having diameters of ⅛, 3/16, ¼, and 5/16-inch are available for each machine. By the use of the proper torsion bars, a large angular displacement of the friction-coupling halves can be obtained with any torque load applied, thus virtually eliminating any change in load caused by gear-tooth wear as the test progresses. The torsion bars are mild steel. Maximum torque capacity, using the 5/16-inch diameter bars, is considered to be 180 lb-in.

Method of Driving: Each machine is driven by a ½-hp, 1725-rpm motor through an adjustable-speed device. Infinitely variable operating speeds from 600 to 5000 rpm are thus available.

To permit investigation of friction losses in the gear teeth, a flexure-plate coupling was built into each machine. This is shown schematically in Fig. 1. It consists of a steel flexure plate clamped at its center to the shaft driven by the adjustable-speed unit. An aluminum shroud containing two steel pins pressed into place 180 degrees apart is splined onto the first gear shaft. Thus the shroud is driven by the flexure plate contacting the steel pins.

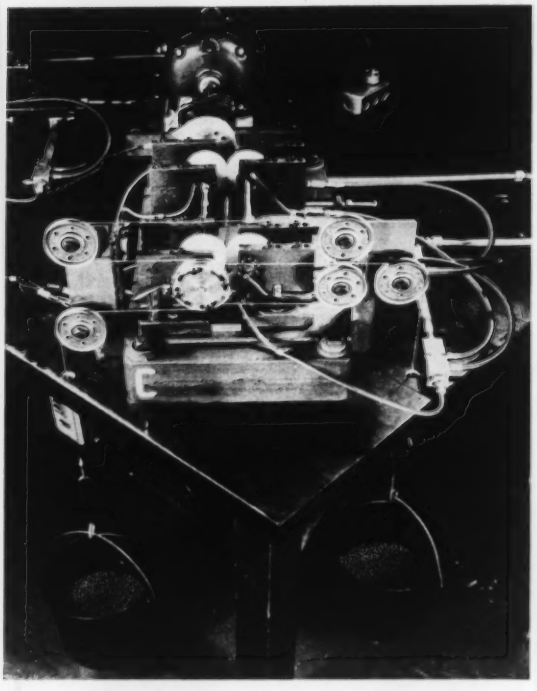


Fig. 2—Method of loading gear teeth.

Bonded SR-4 strain gages mounted on the flexure plate indicate the strain and, hence, the torque being supplied to overcome friction and windage in the test machine. Four active gages are used, connected to form a Wheatstone bridge as illustrated in Fig. 3. To facilitate replacement of the strain gages, the connecting is done at a fiber disk immediately adjacent to the flexure plate. The circuit to the strain-gage indicator is completed by four silver slip rings and carbon brushes.

The flexure plate works well provided the drive runs smoothly with little or no vibration. To obtain the required smoothness, however, several changes had to be made from the original method of supplying power to the test machines. The machines were at first assembled with ¼-hp, 1725 and 3450-rpm motors driving through V-belts with adjustable pulleys to obtain the desired speed variation. This proved to be impractical, however, since at high speeds the entire power output of the motor was absorbed by vibrations of the belts.

The use of short V-belts with fixed pulleys reduced the vibration considerably and allowed the ¼-hp motors to drive the machines without difficulty. However, small variations in the cross-section dimensions of the belts caused short but constantly recurring periods of acceleration and deceleration of the test machines. This condition causes no harm in most machines, but with the sensitive flexure plate these changes in speed and load caused the strain-gage indicator to fluctuate excessively.

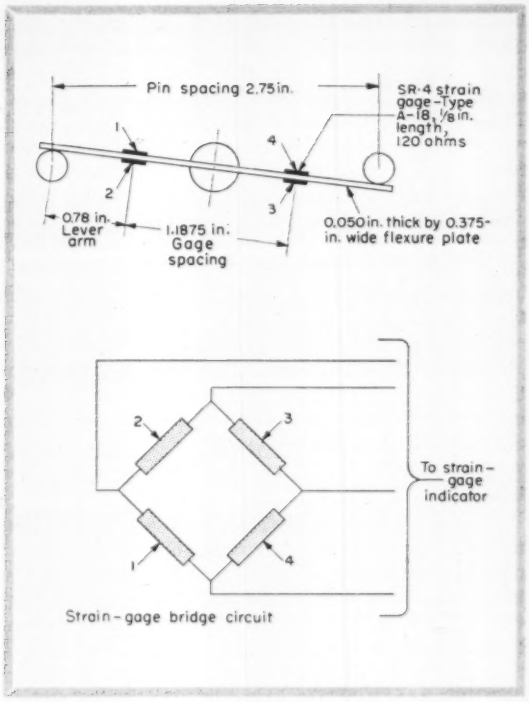


Fig. 3—Flexure-plate strain-gage circuit.

The present drive system, which consists of a motor and a mechanical speed-adjusting unit in line and coupled with 6½-inch pieces of rubber hose, proved to be a good solution to the problem. The speed-adjusting unit contains a traction drive through cones and balls, and is very smooth. Even so, unless the hose couplings are used, alignment of all three units must be virtually perfect to allow proper functioning of the flexure plate. With the hose couplings a reasonable amount of misalignment has no harmful effect.

The flexure plate is calibrated statically. While the shaft beyond the flexure plate is held with a wrench, weights are hung from the friction coupling to develop a known torque. Strain readings are plotted against torque to form a calibration curve. It is felt that this calibration is not appreciably affected by the speed of rotation of the flexure-plate assembly and, hence, that no significant error is introduced by the use of this static calibration.

Lubrication: The test machines are lubricated by individual oil-mist systems. Tubes carry the mist to each bearing and to the test gears. The quantity of lubrication can thus be controlled as desired. When the test gears are to be operated without lubrication, the mist system is shut off and the bearings are packed with grease.

Bearing Testing: With a slight change in assembly, this same machine is used to measure the friction torque in its own ball bearings under various conditions of load and speed. This is a necessary part of the investigation of gear-tooth friction.

To measure the friction torque of the eight bearings supporting the test gears, the machines are assembled as shown schematically in Fig. 4. Bearings from the rear shafts are installed in place of the gears on the front gear shafts. Load is applied by spring scales to each of the bearing assembles through the steel bearing rings shown. Thus, all four bearings in each assembly carry the same load. The torsion bar connects the two front gear shafts and allows the motor to rotate both shafts and their bearing assemblies. The flexure plate records the torque required to rotate this assembly. This is the torque required to overcome bearing friction and windage losses in the rotating assembly.

Gear Testing: Before starting the gear testing, the center distance of the gear shafts must be carefully set to the desired value, and the backlash, or clearance, between the gear teeth measured. A ground-steel bar having the same outside diameter as the ball bearings is installed in the rear bearing supports. The rear bearing supports are adjusted until the distance between the ground bar and the outside diameter of the front bearings is sufficient to provide the desired center distance. This distance between the bar and bearings is measured with gage blocks, and in this way the center distance can be readily set within 0.0005-inch of the desired value.

Backlash: Because Zytel 101 is a plastic material, it is difficult to establish the backlash by the common procedure of mounting a small indicator with its pointer on one tooth, holding the other gear, and rotating the first to determine the clearance. The soft teeth deflect readily, making it difficult to tell when the clearance has been taken up. A special device anchors the left-hand gear and clamps an indicator on the right-hand gear. The weight of the dial indicator tends to rotate the right-hand gear clockwise, thus taking up the clearance between the teeth. A small weight hung on the cord over a pulley then exerts a counterclockwise torque on this same gear, rotating it to take up the clearance in the opposite direction. The

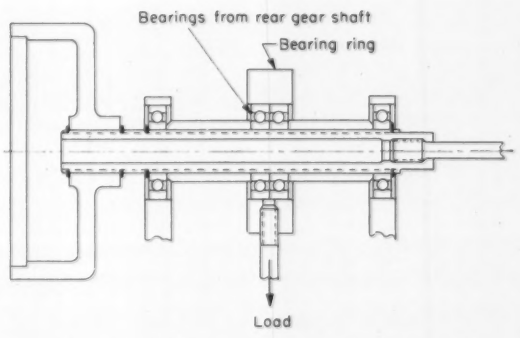


Fig. 4—Layout of bearing-friction test setup.

change in indicator reading multiplied by the ratio of the lever lengths involved is taken as the backlash.

Dynamic Characteristics: To permit investigation of dynamic action of the gear teeth and resulting variations in torque load on the torsion bars, provisions are made to mount strain gages on the short torsion bar and to bring the circuit out through rings and brushes.

During the endurance testing of the gears, flexure-plate strain readings are taken every half hour.

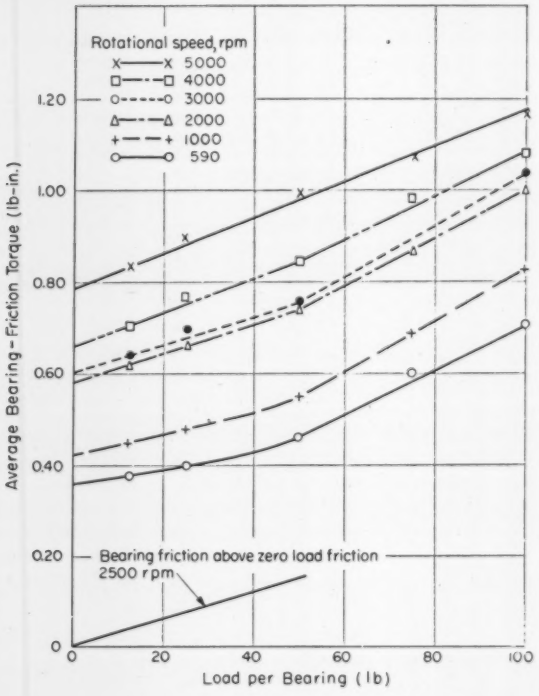


Fig. 5—Plot of average bearing friction torque for one testing machine versus load per bearing. Machine contained eight ball bearings.

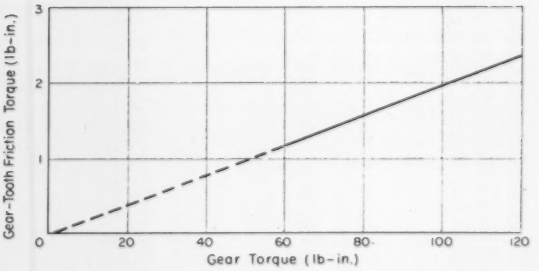


Fig. 6—Gear-tooth friction torque versus gear torque. Data are based on 16-pitch gears with 40 teeth, 20-degree pitch angle, 7/16-in. face width. Teeth were oil-mist lubricated and operated at 2500 rpm.

Immediately after the reading the machine is shut down, the flexure plate freed of contact with the driven pins by rotating the shaft backwards a slight amount by hand, and a zero reading is taken. The difference between these two readings is used with the flexure-plate calibration to determine the torque being supplied to overcome windage and friction in the test machine. At the start and at the close of each day's operation, similar data are obtained with the machines running but with no load on the gear teeth. The no-load flexure-plate readings are used with the bearing-friction data to determine the friction torque of the gear teeth only.

Test Results: The gears are removed for inspection at intervals during the endurance tests, and in this way wear rates and other information are obtained. Only those test results that indicate the way in which the machines perform are mentioned here, however.

The chart in Fig. 5 shows ball-bearing friction torque as measured by the machines. It will be noticed that this friction torque is not zero when the bearing load is zero. Instead, the zero-load friction torque increases with the speed of rotation. It is reasoned that this zero-load friction torque is caused by clamping forces exerted on the bearings by the bearing caps, by the balls sliding against their cages, and by windage. Hence, this same friction is measured when the gears are operated without load at the start and at the close of each day's operation.

The increase in bearing-friction torque above the zero-load friction torque shown in Fig. 5 is considered to be caused by the bearing load and hence is not included in the readings taken when the gears are operated without load. Therefore, to determine the torque required to overcome friction in the gear teeth only, the torque required to drive the machine with no load on the gear teeth is subtracted from the torque required to drive the machine when the teeth are loaded. From this difference is subtracted the bearing-friction torque above zero-load friction torque to obtain the gear-tooth friction torque. The bearing-friction torque above zero-load friction torque is obtained by drawing curves similar to that shown at the bottom of Fig. 5. Drawn parallel to the 2000 and 3000-rpm curves, it is used in the determination of gear-tooth friction torque at 2500 rpm.

Typical results obtained with this procedure are shown in Fig. 6. Note that gear-tooth friction is shown to be zero when no torque is being transmitted. This would seem to verify the validity of the procedure used to determine the gear-tooth friction torque.

During the test work sets of gears have been interchanged among the machine to see if the various machines could reproduce the same gear-tooth friction torque results. Although the magnitudes of the flexure-plate strain readings varied with the five machines, essentially the same results were obtained with the same gears in different machines. This further illustrated the validity of the method and the reliability of the machines.

Recommended details for

Blind Tapped Holes

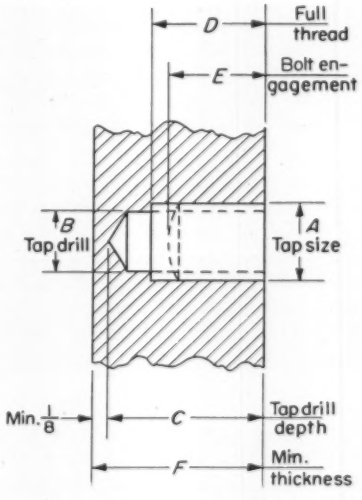
MACHINE DESIGN Data Sheet

By P. A. Unverzagt
Assistant to Chief Engineer (Mechanical)
Allis-Chalmers Mfg. Co.
Pittsburgh Works
Pittsburgh

TAP DRILLING of blind holes can often be troublesome. Without proper specifications, several troubles may arise. At one extreme, the drill may break through. Or, at the other, the tap drilling may be too shallow to allow for sufficient bolt engagement. Also, if these details are not properly worked out, bottoming taps may have to be used, instead of starting or plug taps.

Adhering to the recommendations in the accompanying chart will prevent these possible difficulties. The suggested proportions have been developed for more or less standard conditions. They can be altered in some details, but the relationship of dimensions *C, D, E* and *F* must be maintained.

For example, the minimum recommended thickness (*F*) for a ½-13 thread is 1⅛ in. If this thread size is required in a blind hole in stock only 1 inch thick, and thread loading is not critical, dimensions *C, D,* and *E* may all be reduced by ⅛-in. The differences between them should not be permitted to become less.



A	B	C	D	E	F
8–32	0.136 (29)	1/4	3/16	5/32	3/8
10–32	0.159 (21)	3/8	9/32	7/32	1/2
10–24	0.1495 (25)	3/8	9/32	7/32	1/2
1/4–20	0.201 (7)	1/2	3/8	5/16	5/8
5/16–18	0.257 (F)	5/8	5/32	3/8	3/4
3/8–16	5/16	3/4	9/16	15/32	7/8
1/2–13	27/64	1	3/4	5/8	1 1/8
5/8–11	17/32	1 1/4	15/16	25/32	1 3/8
3/4–10	21/32	1 1/2	1 1/8	15/16	1 5/8
1–8	7/8	2	1 1/2	1 1/4	2 1/8
1 1/2–6	1 21/64	3	2 1/4	1 7/8	3 1/8

All dimensions in inches.

Selecting and applying

AC Push-Pull Solenoids

By I. Gebel
Soreng Div.
Controls Corp. of America
Schiller Park, Ill.

THE function of a solenoid is to actuate valves, clutches, brakes, pumps or any device requiring controlled motion. This discussion outlines characteristics of ac solenoids of the types used on washers, dryers and other appliances.

Types of Solenoids: In general, the push-pull type of solenoid can be classified according to plunger and frame construction:

Type	Construction
Iron Clad	Solid frame and plunger.
I	Straight plunger and C-shaped frame.
T	T-shaped plunger.
TT	Double T-shaped plunger.

Most dc solenoids are of the iron-clad type. For ac operation, solenoids required to pull substantial loads are laminated to reduce iron losses. Comparative performance of these types of laminated solenoids is shown by the pull-curves, Fig. 1.

These pull-curves have been made on solenoids of the same physical size and coil winding. The "drop" in the pull curves of the I and T type solenoids has been overcome largely with the Double-T solenoid construction. Since most loads increase progressively with the stroke, allowance for the drop reduces the output of the entire solenoid. Some failures have been attributed to this drop in the I and T solenoids where inertia of the plunger was depended upon to overcome decrease in pull.

Pull Characteristics: When a solenoid is energized its magnetic field exerts a pull on its plunger in a series of pulses at double the frequency of the current. Hence, the load moves under varying force, in about 1/20 to 1/12-second, depending on stroke and load, to the seated position, where the pull becomes steady. In the seated position, the resulting magnetic field produced by the coil and shading ring takes effect.

The dynamic solenoid action is not duplicated by the methods used to determine the pull-curve characteristics. Since the measurements of pull are made at static conditions, the inertia effects of the load are not included. It is also necessary, when using the pull curves, to take into account the weight of the plunger. The pull curves developed by the so-called continuous method have the weight of the plunger omitted, since most solenoids are operated in a horizontal position.

Solenoid Duty: Misunderstandings exist in the interpretation of so-called "constant" and "intermittent" duty solenoid operation. Although these terms are commonly used, they are relative expressions. The degree of constant or intermittent duty is governed by the application in regard to acceptable maximum temperature rise.

In the case of Class A insulation, the maximum temperature is 105 C. The Underwriters' Laboratory accepts a maximum temperature rise of 65 C, measured with a thermocouple.

Heat produced in the solenoid is caused by copper and iron losses. The temperature rise as a result of this heat will depend upon the length of time the solenoid is energized, number of operations, heat conductivity, heat radiation and ambient temperature.

Thus, operating conditions to which the solenoid is subjected will govern the ultimate temperature rise. In appliances, the solenoid is generally mounted on a metal plate which provides good heat conductivity.

On this basis, a solenoid energized continuously and not exceeding 65 C (with thermocouple) has been termed "constant" duty. Conversely, a solenoid that would exceed 65 C rise by continuous operation would require, on the same basis, current interruption to be within the temperature limits. This

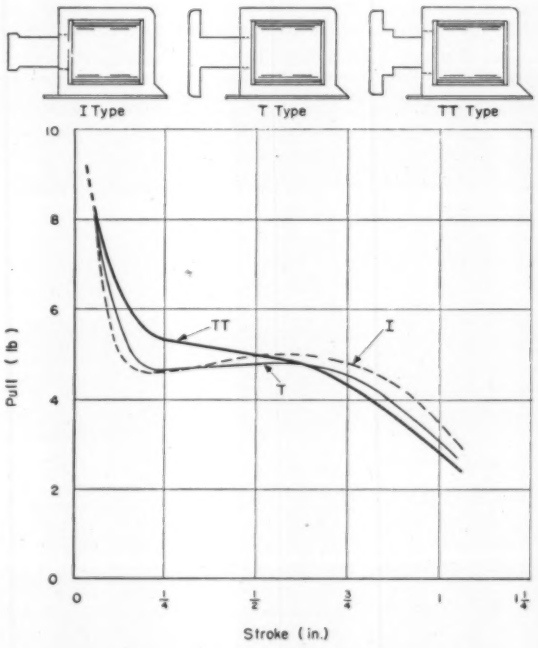


Fig. 1—Comparison of pull-curve characteristics of I, T and TT type solenoids operated on 110-v, 60-cycle ac at a 95 F starting temperature. Coils for all three types have 1135 turns of No. 27 wire. Lamination size is 2 x 2 in. stacked ¾-in. high.

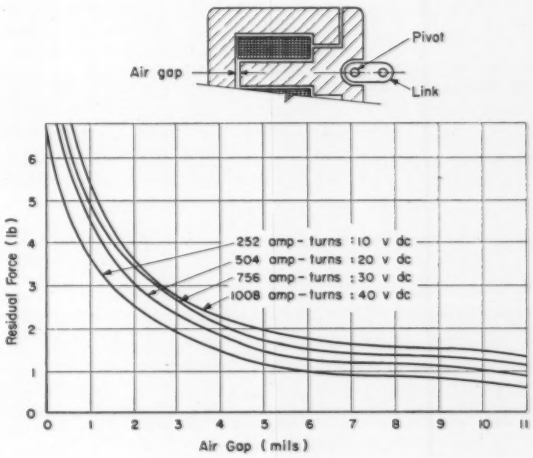


Fig 2—Relationship between residual force and fixed air gap in solenoid with coil having 2100 turns of No. 32 wire.

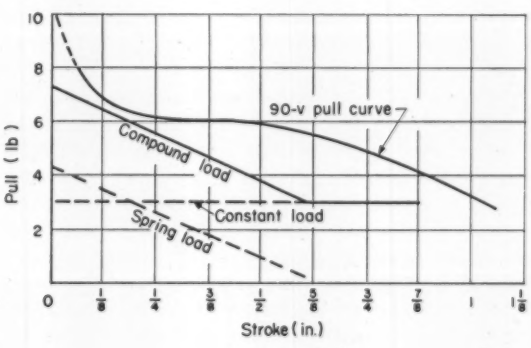


Fig. 3—Method of matching load to pull curve.

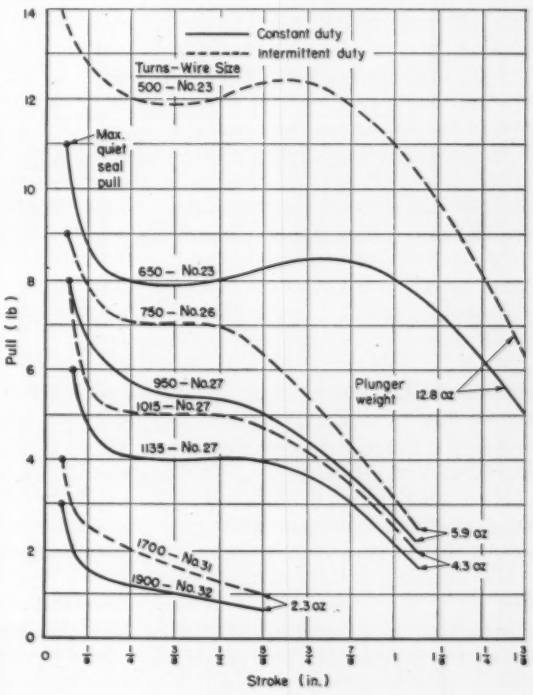


Fig. 4—Comparison of pull-curve characteristics of various solenoid sizes operating at 90 v, 60 cycles and 95 F starting temperature.

solenoid would then be termed an "intermittent" duty type.

In the final analysis, regardless of the terms "intermittent" or "constant" duty, a Class A insulated solenoid, according to Underwriters', to be acceptable, cannot exceed 65 C during its function for a period of six successive complete machine operations with 3-minute "off" periods between complete cycles.

Line Voltage: The voltage supply available to equipment varies in different localities. For example, in homes it can range from 90 to 130 v; the average is about 117 v.

Minimum voltage specified for solenoid operation ranges from 90 to 100 v. Most solenoids, however, are required to operate the load at 90 v. With the large electrical loads being used in the home today, it is probably safer to specify 90 v operation.

Obviously, a solenoid designed for 90 v operation will have more energy at 120 or 130 v. This excess energy results in greater plunger impact and objectionable "slam." However, some compromise is necessary to insure operation of the solenoid at low voltage.

Too low a voltage is not recommended. Seating surfaces of the plunger and frame wear more rapidly from the higher impact. This change in seating surfaces reduces the air gap at the end of the plunger and thus increases the residual force which holds the plunger after the magnetizing force is removed. Tests indicate that about 50 million operations with a matched load will reduce the air gap 0.001 to 0.002-in.

Since on practically all applications the load increases with the stroke of the plunger, a slight increase in residual force has no effect on holding the plunger after the current is interrupted. Fig. 2 shows the relationship between residual force and fixed air gap.

An antiresidual spring is provided to overcome some of the residual force. The force of this spring is maintained low, about 1 to 3 lb, depending on solenoid size, in order not to detract too much from the so-called quiet seal pull. The antiresidual spring force is not sufficient to overcome the residual force under all conditions. If, for some reason, the solenoid is considerably underloaded, additional antiresidual spring force will be needed to prevent the plunger from sticking.

The voltage considered should be measured at the solenoid, to take into account the voltage drop through the appliance. A momentary high voltage drop occurs when the motor in a piece of equipment is started. It would, therefore, not be desirable to energize large solenoids at the same time the motor is started.

Load Characteristics: To obtain the maximum performance in a solenoid, the load should be matched to the particular pull curve. Selecting a larger solenoid, with considerably more pull than required, causes excessive impact. The excess energy is absorbed in the frame and plunger and as a result the rate of wear is increased.

The plunger stroke should be as short as possible to reduce impact and wear. This is especially desirable where the load is constant. With a constant load it would be favorable to add a spring load to decrease the excess energy. A compound load of this type is illustrated in Fig. 3.

The pull curves shown in Fig. 4 represent the characteristics of four sizes of solenoids. It will be noted that the curves are ended between $\frac{1}{16}$ and $\frac{1}{8}$-in. stroke. Although the pull increases further, an audible chatter will develop if loaded beyond quiet seal pull. This seal pull limit should not be exceeded if quiet operation is to be maintained. It is preferable to allow 5 to 10 per cent lower seal pull than indicated by the curves for added safety.

Method of Mounting: Most of the problems encountered with solenoids develop from incorrect mounting. For maximum performance the solenoid should be mounted with the plunger either vertical or horizontal. At no time should the solenoid be mounted on a side, since excessive wear may result. This may cause the plunger to stick and, in turn, possible burnout of the coil.

In most applications, the solenoid is mounted directly on a steel plate. To prevent excessive flux leakage and subsequent loss of power, a section in the steel plate directly under the plunger should be removed for the full length of the stroke. Raising the solenoid off the steel plate about $\frac{1}{8}$-in. will accomplish the same results. However, if a close temperature problem exists, it is preferable to mount directly on the steel plate to obtain the maximum heat conductivity.

External plunger stops are recommended since the internal stops are not ample for extended operation. The external stop should be nonmagnetic to avoid flux leakage. Usually, if the stop is made directly from the mounting plate, a rubber sleeve or bumper serves to prevent metal-to-metal contact. Also, the plunger impact is absorbed on the return stroke.

There are various types of mounting means used. For off-center loads it is necessary to pivot the entire solenoid to prevent tangential forces on the plunger. A back-end pivot bracket is utilized. End mounting brackets can be used for vertical operation of the solenoid.

To reduce the impact effect due to excess energy, rubber or a spring mounting can be used. The heat conductivity is somewhat reduced with this type of mounting which, in turn, raises the temperature of the coil slightly. This can be avoided if the solenoid is first mounted on a steel plate that is supported by rubber.

Connecting Plunger to Load: For the best solenoid performance, the load should be directly in line with the center line of the plunger action. This requirement is not always possible where a pivoted lever is being actuated. Under such a condition, the length of the lever should be sufficient to cause very little displacement of the plunger.

In the seated position of the plunger, the load must be in or near the geometric center of the solenoid. A flexible linkage, such as a spring or link, is useful for connecting the lever to the plunger.

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—ITEM 541—

will automatically provide overtravel and make allowance for slight displacements in all directions.

At all times, the plunger must have freedom of movement. Any restriction may cause binding and burnout of the coil. Sufficient overtravel of the lever must be provided to permit the plunger to seat on the frame; otherwise chatter and perhaps overheating may result.

Within the past few years, solenoids have been provided with a link imbedded in the center of the plunger as shown on the solenoid sketch in Fig. 2. The pivot connection is located in line with the seating surfaces of the plunger. Thus, more movement is provided which insures quiet solenoid operation. This link is especially useful where the connection to the lever is of necessity close or where possible slight tangential forces may occur. This link is also convenient for a spring connection to the lever.

From a paper entitled "Application of Solenoids to Appliances" presented at the AIEE Conference on Domestic Home Appliances in Milwaukee, Wis., May 1956.

Developing Technical Managers

By A. Pemberton Johnson

Testing and Guidance Div.
Newark College of Engineering
Newark, N. J.

ALL too often an organization may suddenly discover that a particular manager's position will be open and a replacement is needed. Consideration of the position and of available men reveals that a certain man is best qualified. He is immediately placed into the position and his superior then turns to other problems which have accumulated while he tackled this one.

Although possibly necessary on occasion, this procedure is not so likely to pay off in the long run for any organization, as is a systematic, long-term program of fostering the self-development of young technical men toward management responsibilities, and the systematic try-out and evaluation of these men in positions of increasing responsibility for the work of other people and for technical matters.

Consider a technical manager, Bill Smith, one of whose critical functions was "to supervise design modifications which will reduce production costs." His supervisor, soon after he was placed in this technical managerial position, might have said, "Bill, the way our company is growing we will probably want to promote you to a more responsible position in a few years. Wouldn't it be a good idea for you to look around among the engineers in your department and try to pick out two or three who are good engineers and are particularly well liked by the other men so you can try them out several times in supervising and training other men, particularly any newcomers? In this way you could relieve yourself of training all the new people, you would gain some time to catch up where your background for this position is weak, and you would be developing one or two men who could take over as soon as something opened up for you." Then, if Bill's superior checked back with him every six months or so to ask which of Bill's subordinates had done best in supervisory try-outs, not only Bill and his supervisor but the most promising subordinate would be ready after a year or two for a more responsible role.

Information which can be obtained from a patterned or structured interview and from psychological tests supplements on-the-job information regarding how well an engineer or scientist can stimulate useful creative thinking among his subordinates, delegate responsibility and authority, develop supervisory capacity in selected subordinates, exhibit a sound economic sense, co-operate as a team member, manage his money, time and energies, and place the welfare of his associates ahead of his own welfare. Conducting and interpreting the results of both a patterned interview and selected psychological tests ought to be done by or under the supervision of an experienced psychologist who has worked with industry.

Some findings, reported last summer in a psychological study of top executives earning $20,000 a year or more, showed that all had so identified themselves with their companies that they derived a great deal of their job satisfaction from the growth and development of their companies. They were healthy, well-rounded individuals, who had a good many lasting friendships, who had high moral and religious standards, high intellectual ability, and interests primarily persuasive, literary and computational in nature, rather than mechanical, scientific or related to social service.

Another recent study of five levels of management, including two levels of managers who were primarily technical managers, showed very nearly the same widespread normal distributions of personality test scores as might be found for an unselected group. Problems not met in this study were assessment of competence of these managers in their positions, and the probable great diversity in the critical functions of greatest importance in their positions.

From a paper entitled "The Selection of Technical Managers" presented at the ASME Semi-Annual Meeting in Cleveland, June, 1956.

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HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Corrosion Resisting Castings

Chart 556-C of corrosion resistant stainless steels for castings gives ACI and Empire designations with corresponding AISI type number, ASTM designation and other trade names of similar alloys. Percentages of principle alloying elements and typical mechanical properties of the 23 listed steels are given. 4 pages. Empire Steel Castings, Inc.

—Circle ITEM 401

Solenoids

Alternating and direct current solid frame solenoids for continuous and intermittent duty are detailed in illustrated bulletin 200. Also covered are laminated ac solenoids. Graphs of performance data and size and mounting data are given. 6 pages. Comar Electric Co.

—Circle ITEM 402

Weldments

Seven benefits offered to users of weldments when they specify BLH are explained in bulletin 7001. Attention is given to the fabrication of large custom-designed weldments such as pressure vessels, bridge structures and tanks. 6 pages. Baldwin-Lima-Hamilton Corp.

—Circle ITEM 403

Self-Lubricating Bearings

Illustrated stock list S-56 contains complete details on sleeve, flange and thrust bearings; cored, bar and plate stock; and standard self-lubricating Oilite bearing material. Engineering data section deals with properties, loads and speeds, chamfers and filets, installation, sizing, tolerances, machining and lubrication. 24 pages. Chrysler Corp., Amplex Div.

—Circle ITEM 404

Plastics & Laminates

Silent Celoron gear stock; and molded-laminated, molded-macerated, transfer molded, injection molded and custom-molded Celoron synthetic resin products are detailed in catalog C56. Gear design data and tables as well as engineering information are presented. Use of material for phenolic parts with good mechanical strength is discussed. 16 pages. Budd Co., Continental-Diamond Fibre Div.

—Circle ITEM 405

Electric Eraser

Usable by draftsmen, engineers and others who have need for fast, effortless erasing of pencil, ink and typed copy, the automatic electric eraser is detailed in bulletin F 3579-1. Tool has chuck for easy adjustment or replacement of eraser tip. 4 pages. Barber-Colman Co., Small Motors Div.

—Circle ITEM 406

Beryllium Copper Alloys

Reference data for engineers and designers on Berylco beryllium copper casting alloys are presented in bulletin. Five sections cover available alloys, properties, advantages, casting and processing techniques. Reference charts and tables amplify text. 12 pages. Beryllium Corp.

—Circle ITEM 407

Technical Ceramics

The latest information on the mechanical and electrical properties of AlSiMag technical ceramics is detailed in bulletin 563. Presented in tabular form, data covers vitreous ceramic, lava and refractory materials. Selection charts and thermal expansion graphs are included. 4 pages. American Lava Corp.

—Circle ITEM 408

Fluid Flow Control

The Askania Transometer comprises a positive-displacement type flow meter and a pneumatic signal transmitter. It will meter oil, viscous fluids and other liquids. It can also integrate and provide pneumatic signal for flow indication, recording and control. Full data are given in bulletin 301. 8 pages. Askania Regulator Co.

—Circle ITEM 409

Lubricants

Published in the interest of complete lubrication information for industry, "Lubrication Newsletter" is a regular publication dealing with molybdenum disulfide lubricants and their use. Design and engineering personnel interested in lubrication will be placed on the mailing list to receive this bulletin regularly. 4 pages. Alpha Molykote Corp.

—Circle ITEM 410

Sleeves, Boots, Pliable Parts

Fourteen different designs for sleeves, boots, way protectors and related pliable parts fabricated to order from a neoprene-base material are shown in bulletin SPC-2. Almost any size or shape can be produced. 2 pages. A & A Mfg. Co.

—Circle ITEM 411

Rapid-Reversing Motors

Blower-cooled rapid-reversing motors capable of more than 200 idle reversals a minute are described in bulletin 1800. Cutaway view shows construction features. Engineering information given includes formulas for inertia and motor reversal calculations. Louis Allis Co.

—Circle ITEM 412

Rivets, Studs & Caps

Detailed descriptions of 1388 standard semi-tubular, full tubular and split rivets, bag studs and rivet caps are content of illustrated price list No. 42. Various metals and finishes are offered. Rivet selection and rivet setting machines are covered. 16 pages. Chicago Rivet & Machine Co.

—Circle ITEM 413

Carbon Steel Tubing

Condensed data on mechanical and physical properties of seamless and welded carbon steel pressure tubing are found in technical folder TDC-142A. Information of various fabricating operations are included. 4 pages. Babcock & Wilcox Co., Tubular Products Div.

—Circle ITEM 414

Resolvers & Servos

Illustrated bulletin 374 contains specifications and characteristics of 36 precision resolvers offered in size 10, 11, 15 and 23 frames. Data on 60-cycle and 400-cycle magnetic servo amplifiers, including application information, are found in bulletin 382. Specs and gear ratios for

Emerson-Electric engineering highlights

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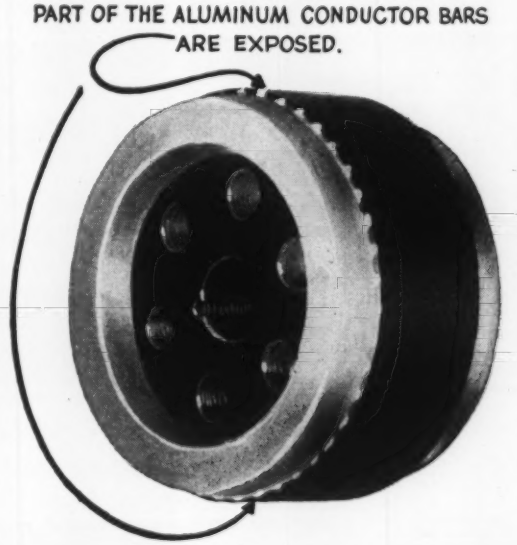
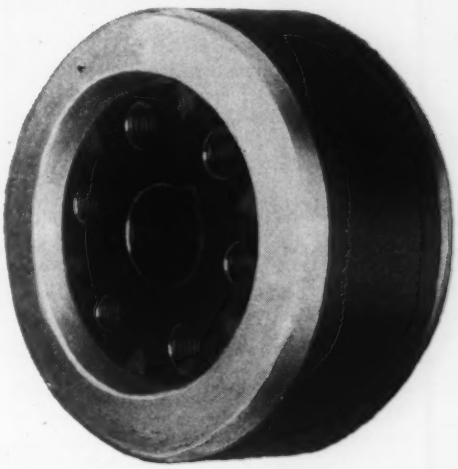


NEW, IMPROVED EMERSON-ELECTRIC ROTOR END-RING DESIGN, WHICH ELIMINATES NEED FOR FINISH TURNING.



New end-ring design assures more years of trouble-free service, provides superior strength, durability and operating efficiency

The introduction of the improved Emerson-Electric rotor-end-ring design obsoleted ordinary rotor construction. It was unreliable and often resulted in motor trouble, also possible damage to associated equipment.

This was due to the fact that in chamfering, or finish-turning the rotor periphery, steel and aluminum flakes were often left on the cut. In a power motor, these chips or flakes could lodge between the current-carrying wires of the stator winding and cause a short. In a hermetic motor, if the chips got past the winding, they would certainly become lodged somewhere in the refrigeration system and could cause a compressor to fail.

Now, Emerson-Electric rotor-end-ring design has eliminated these damaging possibilities, by eliminating the need for chamfering.

Basically, with this new design, no active material is removed from the rotor—therefore, no chips can be left to cause damage or failure of the unit!

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This is but one of many Emerson-Electric "highlight" features that appeal to designers and manufacturers of motor-driven equipment. It is another reason why Emerson-Electric has been recognized as a leader in the design of motors for more than 60 years.

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—ITEM 542—

For More Information Circle Item Number on Yellow Card—page 19

various sizes of gear head servo motors are in bulletin 371. 4, 4 and 2 pages. Norden-Ketay Corp.

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Tape & Imagination

Improvement in products and industrial operations with resultant cost savings can be brought about by application of Dutch Brand industrial tapes and related products. "Imagination and the Man" is an illustrated brochure which shows many applications. 20 pages. Johns-Manville, Dutch Brand Div.

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Air & Hydraulic Valves

Pocket-size folder BV-1 shows MV series valves for air or oil hydraulic service to 200 psi. Valves are available in ⅜, ½, ¾ and 1-in. port sizes. Modernair Corp.

—Circle ITEM 417

Shock & Vibration Isolators

Design procedure for application of shock and vibration mounts to shipboard and vehicular equipment is outlined in product bulletin 56-02. Performance data and characteristic curves for obtaining proper system natural frequency are given. 8 pages. Barry Controls Inc.

—Circle ITEM 418

Hydraulic Components

Pumps, valves and cylinders are examples of hydraulic components which can be produced by this company. Engineering, experimental, inspection, quality control and production facilities are outlined in illustrated brochure. 16 pages. Cessna Aircraft Co., Industrial Hydraulics Div.

—Circle ITEM 419

Grounding Electricity

Various means of grounding electricity for portable tools and equipment are illustrated in bulletin 6440. Revised Code requirements are given for 15 amp, 125 and 250 v devices. Grounding type devices are described and illustrated. 12 pages. Arrow-Hart & Hegeman Electric Co., Wiring Device Div.

—Circle ITEM 420

Directional Control Valves

Three and four-way directional control valves described in bulletin 80300 are for use in fluid power systems up to 3000 psi. Valve body construction details and the functions of standard and special plungers are included. Mechanical, manual, hydraulic and solenoid pilot styles of operators are offered. 16 pages. Oilgear Co.

—Circle ITEM 421

Variable Speed Drives

Features, operating principle, design and component parts of Allspeed variable speed drives are described in bulletin 1600-B7 P. Featuring twin-V tandem belts, compounded sheaves, automatic belt tensioning and constant-speed regulation, drive is offered in 1/3 to 5-hp sizes. 16 pages. Worthington Corp.

—Circle ITEM 422

Relays

Information on Amrecon relays, stocked in 65 different types, is given in catalog R-29. DO and DOS relays are adaptable to severe shock applications; model DOSY, to electronic control circuits; and model CRU, with various contact combinations, for general use. 4 pages. Ohmite Mfg. Co.

—Circle ITEM 423

Air-Conditioning Controls

Ampere ratings of 20, 30, 35 and 50 are offered in air conditioning and refrigeration controls described in bulletin 5610. Controls match single and polyphase starter requirements for current rated motors through 550 v. 8 pages. Furnas Electric Co.

—Circle ITEM 424

Self-Sealing Couplings

"The Case of the Self-Sealing Coupling" analyzes available designs of self-sealing couplings. Discussed are strength, fluid flow, absence of leakage, convenience in connection and locking characteristics. 16 pages. Aeroquip Corp.

—Circle ITEM 425

Large Nuts

Specifications and list prices of large hex, square and special nuts ranging in size from 1¾ to 8 in. are presented in guide book "Large Forged Nuts." Data are given also on large bolts, eye bolts and special fasteners. 36 pages. Jos. Dyson & Sons, Inc.

—Circle ITEM 426

Condensed Motor Catalog

Hundreds of pages of essential data are condensed into this ready reference catalog on motors from 1/20 through 1000 hp. Old and new NEMA ratings are cross-referenced. Current prices cover both fractional and integral horsepower motors. 4 pages. Marathon Electric Mfg. Corp.

—Circle ITEM 427

Large Thin-Wall Tubing

Ranging in outside diameter from ⅝ to 2½ in. and with wall thickness of 0.035-in. or less, large diameter thin-wall tubing is available in seamless and Weldrawn grades. Stainless, nickel, and nickel and alloy, carbon and alloy, beryllium copper and titanium are among the 20 types offered in Data Memorandum No. 4. 5 sheets. Superior Tube Co.

—Circle ITEM 428

Single-Phase Motors

New 10 and 15 hp All-Weather high torque, capacitor-start and capacitor-run single-phase motors available in 1725 and 1140-rpm speeds are featured in descriptive bulletin 470-A. Units are completely protected against weather, debris and small field animals. 4 pages. Robbins & Myers, Inc.

—Circle ITEM 429

Relays & Stepping Switches

Telephone, AN-approved, keying, midget, hermetically sealed and sensitive relays as well as stepping switches, motor starters and contactors, and timers are detailed in catalog C-7. They are available in complete range of contact arrangements and coil ratings. 24 pages. Relay Sales, Inc.

—Circle ITEM 430

Machine Tool Clutch

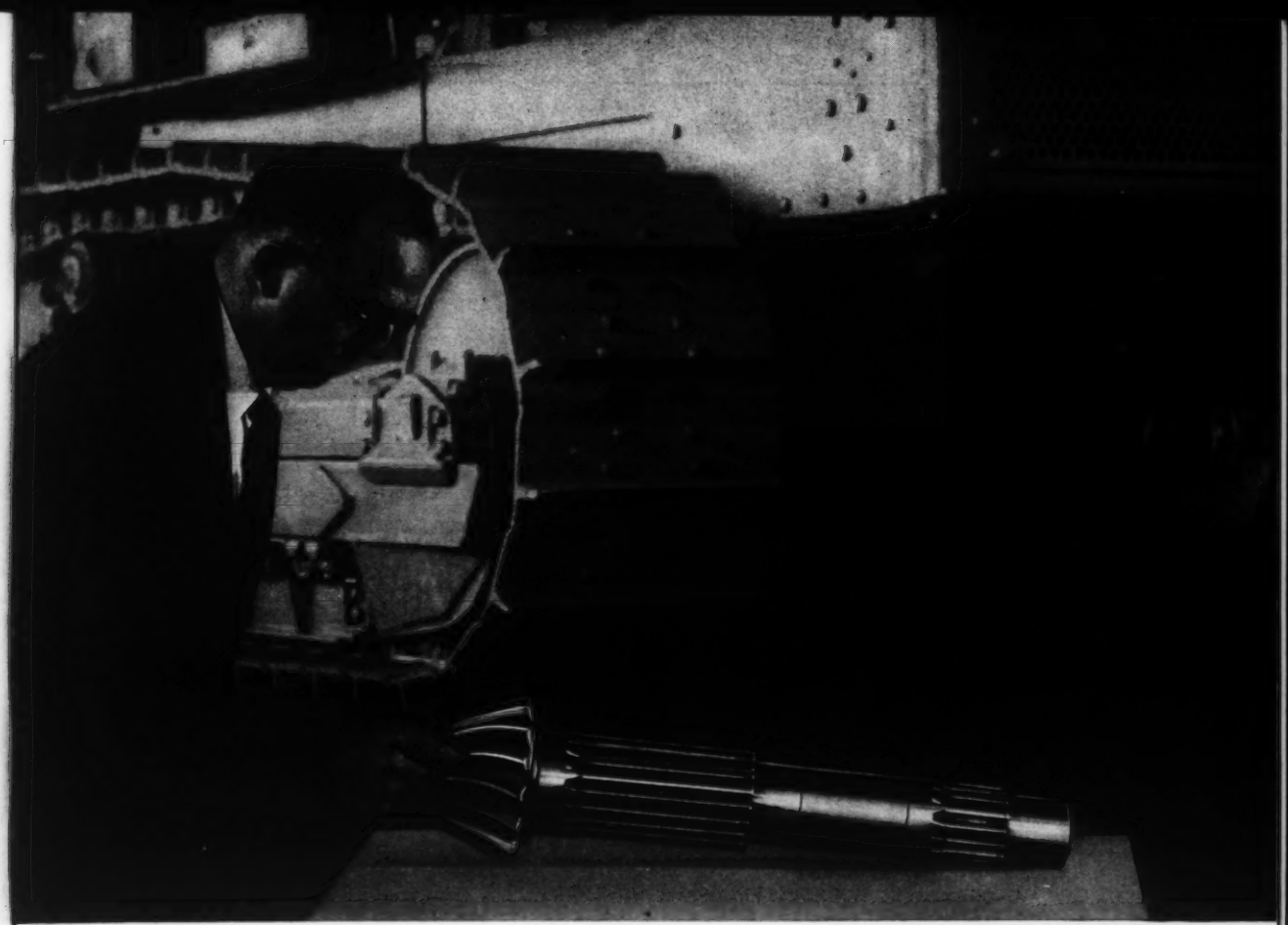
Brochure ECP-656 shows jig borer, automatic turret lathe and horizontal milling machine use of the Electro Clutch. This clutch connects or disconnects a driven shaft or gear from a driving shaft while the latter is either running or standing still. 4 pages. I-T-E Circuit Breaker Co.

—Circle ITEM 431

Hydraulic Oil Coolers

Air and water types of hydraulic oil coolers for industrial hydraulic systems are described in bulletin No. 55-69. Cut-away views show design and construction of these units. Selection charts aid the designer in selecting the proper size and type for a given application. 8 pages. Vickers Inc.

—Circle ITEM 432



Caterpillar Tractor Co. Metallurgist T. H. Spencer inspects final drive pinion for D9 crawler tractor weighing 28 tons. Severe loading of this large pinion requires a steel with high case and core hardenability. Several years ago Caterpillar Tractor Co. found that simply by increasing the molybdenum content of AISI 8622 (to 0.30-0.40%), the desired properties were obtained at lower cost than was possible in any of the standard carburizing grades.

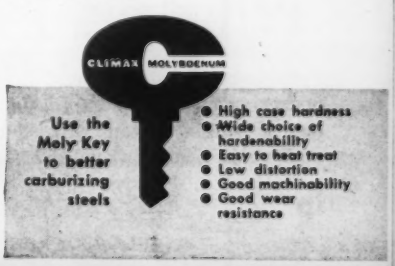
Caterpillar Tractor Co. improves case and core hardenability of carburizing steel by increasing molybdenum content

"Drive pinions in tractors must take very high torque loads," says T. H. Spencer, Metallurgist for Caterpillar Tractor Co. "AISI 8622 steel, which we had been using, couldn't give us the hard case and strong, tough core we needed in these heavy sections. Other standard carburizing steels with the requisite properties would have cost substantially more. We found, however, that we could achieve the desired surface and core properties by simply modifying AISI 8622 with a higher percentage of molybdenum. We have been using this composition for several years, and results have been excellent."

Caterpillar Tractor Co.'s experience shows how increasing molybdenum in a carburizing steel helped to solve a specific problem. Perhaps your product, too, can benefit by higher molybdenum content.

A technical article, "New Carburizing Steels for Critical Gearing", describes some recent investigations of higher-moly carburizing steels. For a reprint, write Climax Molybdenum Company, Dept. 11, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM



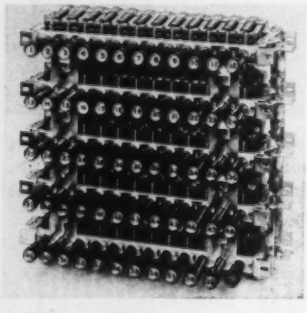
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Ganged Switch

push button unit is versatile circuit controller

Muti-Switch, offering a wide choice of switching functions, is a multiple push button switch with illuminated or nonilluminated push buttons. When stack switches are mounted on separate plates, up to four stacks can be operated by each button, providing innumerable circuit possibilities. Switch



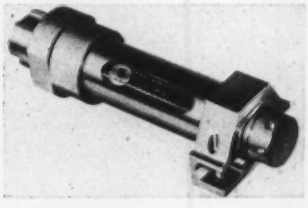
functions available are: Interlock, nonlocking, all lock, interlock and nonlock combinations, all lock and nonlock combinations. Lock-out bars can be provided in switches of two to twelve stations so that only one station can be depressed at a time. Switch mechanism can be solenoid released if desired. Standard distance between buttons is ⅝ in.; special spacing can be provided. **Switchcraft Inc.,** 1328 N. Halsted St., Chicago 22, Ill.

—Circle ITEM 451

Liquid Spring

push-pull unit can be cycled 1040 times per min

Tension-compression liquid spring, operating on liquid compressibility, has a single piston with double action and has been cycled at rates



to 1040 cycles per min. Spring housing measures 1⅝ in. diam by 8½ in. long. Preload is 1100 lb and endload is 11,000 lb. The unit passes all applicable military environmental and life tests. **Taylor Devices Inc.,** 188 Main St., North Tonawanda, N. Y.

—Circle ITEM 452

Nylon Pipe

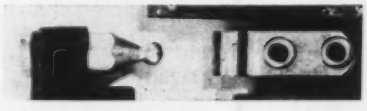
in straight lengths or coils

Tempertube nylon pipe has high bursting strength, withstands high temperatures, and is nontoxic. It is supplied in straight lengths or in continuous coils in sizes from ⅜-in. OD to 1½-in. OD. Wall thicknesses vary from 0.025 to 0.125-in. **Danielson Mfg. Co.,** Danielson, Conn.

—Circle ITEM 453

Printed-Circuit Fastener

holds 12-lb pull-off force



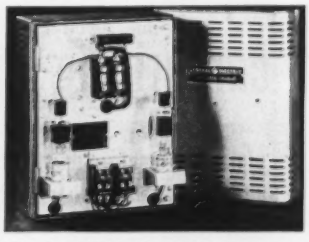
Printed circuit fastener, designed to hold printed circuit cards in place, has three parts: A ball stud and two clips. The ball stud, which also serves as an attaching nut for the contact plug mounting, is made of low-carbon steel, and the two clips are high-carbon steel, spring tempered to hold against a 12-lb pull-off force. In normal applications two fasteners are used. Designed for use on 0.062-in. material, clips measure 0.662-in. by 0.188-in. Length from flat on the base to center of the ball is 0.281-in. **Camloc Fastener Corp.,** 37 Spring Valley Rd., Paramus, N. J.

—Circle ITEM 454

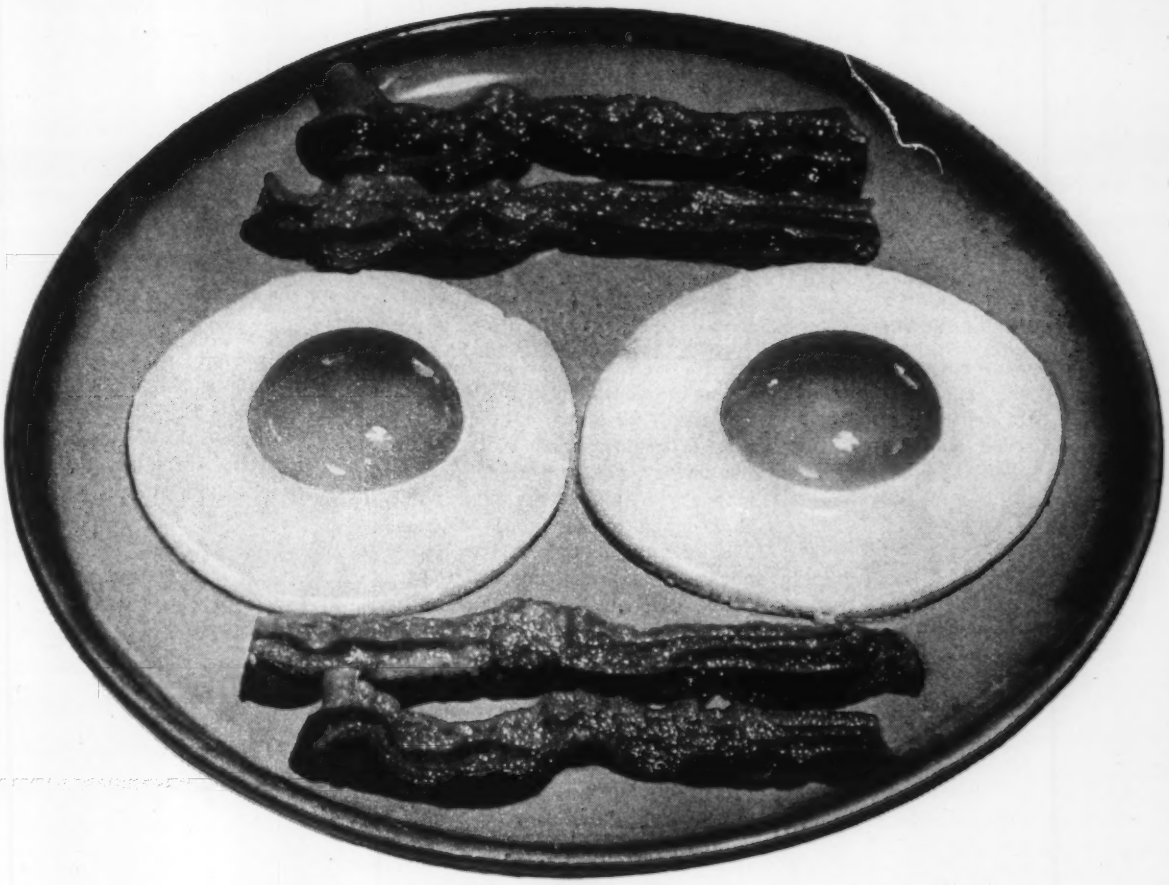
Adjustable-Speed Controller

holds speeds to 3 per cent, provides constant torque

Thy-mo-trol electronic adjustable speed drives, for 1/50 to ¾-hp motors, give precise control of speed with constant torque over the entire speed range. Desired speed can be preset from remote location with a speed-control potentiometer mounted in a control station. Stepless speed control gives an infinite variety of speed



settings within the rated range of the drive. Half-wave unit, employing plug-in printed circuit board, holds speed regulation to 3 per cent, no-load to full-load. Full-wave unit employs full-wave rectification circuit to minimize torque pulsations and gives no-load to full-load speed regulation of 5 per cent. Full-wave drives are available in ratings from ¼ to ¾ hp. Specially designed motors used with the control deliver constant torque over a 20:1 speed range. Standard mo-

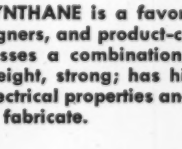


. . . a combination that's hard to beat!

Laminated plastics . . . for a combination of properties that *can't* be beat

SYNTHANE is a favorite material among engineers, designers, and product-conscious executives because it possesses a combination of many properties. It is light in weight, strong; has high dimensional stability, excellent electrical properties and chemical resistance. It's also easy to fabricate.

Synthane makes excellent ball bearing retainers. High dimensional stability, wear resistance and non-galling properties keep bearings humming smoothly at 100,000 rpm and up! Synthane's light weight minimizes the effect of any eccentricities, provides lower starting torques, less bearing weight. The Synthane plant has facilities for producing practically every type of laminated plastic retainer known.



EASILY MACHINED

DIELECTRIC STRENGTH

TENSILE STRENGTH

CHEMICAL RESISTANCE

Property combinations! Synthane has them : . . in over 30 individual grades . . . sheets, rods, tubes, moldings and completely fabricated parts. Send for free illustrated catalog today.

SYNTHANE

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

—ITEM 544—

For More Information Circle Item Number on Yellow Card—page 19

tors are available with drip-proof or totally-enclosed construction; dynamic braking and overload protection are also available. **General Electric Co.,** Specialty Control Dept., 1 River Rd., Schenectady 5, N. Y.

—Circle ITEM 455

Analog-Digital Converter

has sine-cosine output

This sine-cosine analog to digital converter provides 8-bit coding in continuous serial binary form for

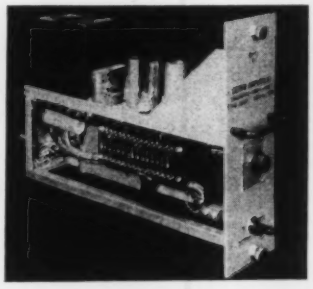
values of the functions from zero to one. Ninth bit is included to enable the encoding of the value one. Each quadrant is divided into 257 parts, with each part representing equal values of the functions. Both sine and cosine values are simultaneously available. Consisting of two disc-type commutators with pick off brushes, the converter avoids output ambiguity. Input shaft is scaled at 360 deg per revolution, full scale input. Diameter of unit is 4 in. and length is 3½ in. Standard synchro-mount is provided on the input shaft end of the unit. Weight is approximately 20 oz. **Librascope Inc.,** 808 Western Ave., Glendale, Calif.

—Circle ITEM 456

Servo Amplifiers

for data transmission, computer and control systems

Model 2307 magnetic servo amplifier is a 400-cycle unit with an output capacity of 18 w; it is suitable for driving 115-v, 400-cycle, two-phase servo motors rated at 18 w per phase. Up to four inputs can be totaled in the input summing network, and any desired ratio of imputs is available. With maximum gain, an 80-mv input pro-

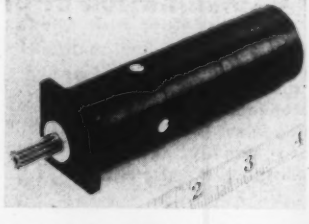


vides full output. Output is 90 deg out of phase with the input to provide proper phase shift for a two-phase motor. Model 2308 magnetic amplifier, a similar unit, is designed to handle the lighter load of any 400-cycle, 115-v, two-phase motor requiring 10 w per phase. Model 2309 vacuum tube servo amplifier is a 400 cycle unit with beam power output tubes and is suited for control of any 115-v, 400-cycle, two-phase servo motor rated at 18 w per phase. For 10-w servo motors, Model 2310 vacuum tube amplifier is recommended. **Servo Corp. of America,** 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.

—Circle ITEM 457

Miniature DC Motor

has 1⅛ in. diam, weighs 12 oz



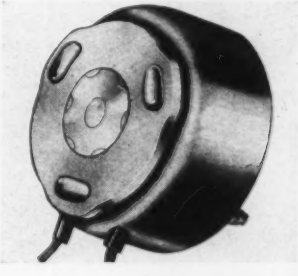
Model 1700-3 fractional-hp planetary-geared motor has integral clutch and is furnished in lead configurations, shaft lengths and shaft diameters to customer specifications. Meeting or exceeding military environmental specifications, it is furnished in a range of output speeds and clutch settings. Input is 28 v dc, 1.3 amp at full load. Output is 150 oz-in. at 60 rpm; clutch setting allows slippage at 165 oz-in. Measuring 4.025 in. long by 1.125 in. diam, the motor weighs 12 oz. Case is anodized aluminum, and ball bearings are permanently lubricated. **El Ray Motor Co. Inc.,** 11747 Vose St., North Hollywood, Calif.

—Circle ITEM 458

Rotary Solenoid

has 1-in. diam, weighs 1½ oz

Linear movement of an armature is converted into rotary shaft motion by ball bearings and inclined races in this ED1E rotary solenoid, which weighs 1½ oz and has a 1-in. diam. Starting torque is 0.2 lb-in., and rotary strokes



range from 25 to 45 deg, either clockwise or counterclockwise. Coil voltage requirements range from 2 to 200 v dc. Larger units with torques to 54 lb-in. on intermittent duty cycle can also be supplied. **G. H. Leland Inc.,** 123 Webster St., Dayton, O.

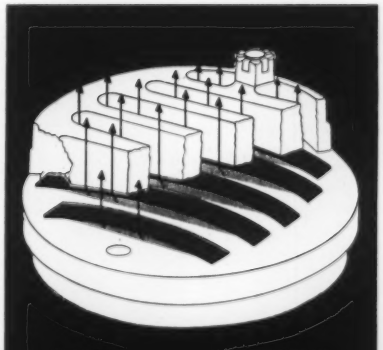
—Circle ITEM 459

Sequence Valves

follow preset operating pattern when actuated

Sequence-type air-circuit control valves, series TD and WV, provide for a preset pattern of operations to be automatically carried out after a cycle is initiated. Cylinders can be sequenced by position or time, and their action interlocked in the circuit. MV valves have immediate actuation and reversal; TD sequence valves have delayed actuation and immediate reversal; WV valves have immediate actuation and delayed reversal. Available models include straightways and three-ways, normally open and normally closed. They are adapted for in-line mounting, in ¼ to 1¼ in. sizes. They are also avail-

This compressor valve works with no impact for longer life, best efficiency



Stainless steel strips, in red, open the Feather Valve ports by rolling contact against the lower plate. There is no impact.

The Feather* Valve is the lightest, simplest, quietest compressor valve ever developed. Flexible strips of stainless steel open and close the valve ports with a gentle rolling contact. There is no destructive impact . . . even when the valve is operating as fast as forty times a second.

This lack of impact assures long life and negligible maintenance. The valve itself is all but indestructible. Absence of buffer plates and cushioning devices give it extreme simplicity.

The Feather Valve is quiet and reliable because of its lightness and tight contact seating. Valve action is very sharp. There is virtually no slip or back flow. As a result, you get minimum valve loss and use minimum power.

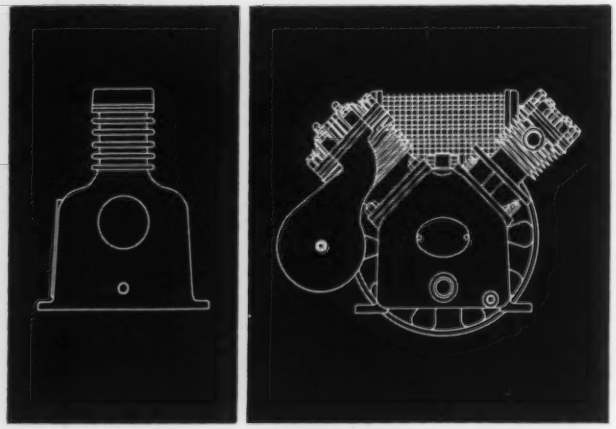
To get the utmost in performance, be sure you specify Worthington when you buy your next compressor. Worthington Corporation, Harrison, N. J. K.6.2

WORTHINGTON

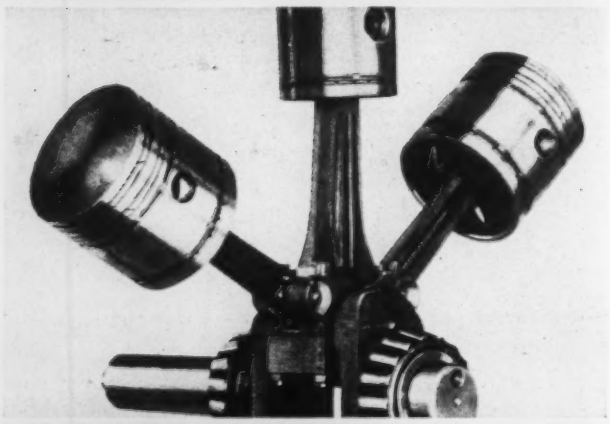
*Reg. U. S. Pat. Off.

WHAT'S YOUR C.Q.?*

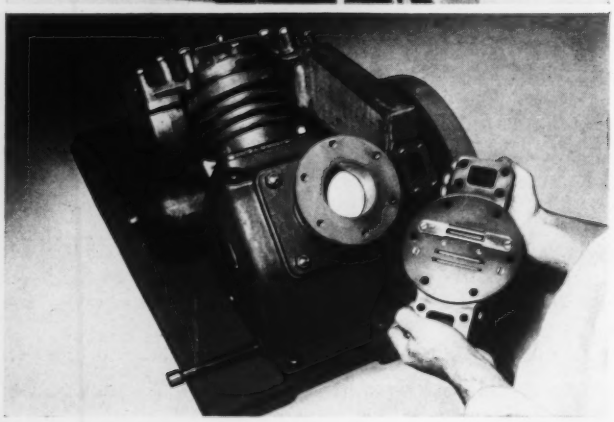
*COMPRESSOR QUOTIENT



In-line or V-type—which is more efficient? In certain fields, this is a hotly debated subject. In compressors, however, most authorities agree that the V-type design provides better balance, smoother running, and better cooling. Besides building only the more efficient V-type design, Worthington casts each cylinder separately from the crankcase. Air thus flows completely around the isolated cylinders, increasing efficiency and saving power dollars.



Why is this connecting rod "aerodynamically" sound? This articulated connecting rod design assures smooth effortless operation, less bearing wear and longer life. It's used in all Worthington radial compressors because it lowers crankpin bearing pressure. One large bearing carries peak connecting rod loads which occur at successive intervals. It's aerodynamically sound because the design is also used in all modern radial aircraft engines.



What important maintenance feature is he demonstrating? When a compressor is operating, valves open and close as many as thirty-three times a second. Valve maintenance is therefore of major concern to all users. Unlike many other makes which require replacement of the complete cylinder or head, all Worthington compressors are equipped with individually replaceable valves and valve guard seats. This is just one of the many Worthington features which save you time and money.

Pc. 6.4

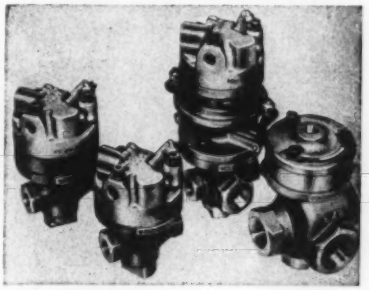
To increase your C. Q., write today for the complete story on Worthington's line of standard compressors. Ask for bulletins H-630-B1 and H-605-B3C. Address Section PC64, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont.

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Air Compressors • Pumps • Multi-V-Drives • Allspeed Drives

XUM



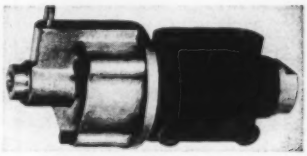
able in 2 in. sizes for MV type operation. **Ross Operating Valve Co.**, 120 E. Golden Gate Ave., Detroit 3, Mich.

—Circle ITEM 460

Time Delay Valve

can be manually preset for 0 to 5 min delay

Pilot-operated time delay valve, which can be remotely positioned and controlled from a central station, provides delayed actuation with immediate reversal, or immediate actuation and delayed reversal. Manually preset delay time



is from 0 to 5 min. Available in two, three, four-way styles, valves are adapted to standard pipe sizes from ¼ to ¾-in. **Airmatic Valve Inc.**, 7313 Associate Ave., Cleveland 9, O.

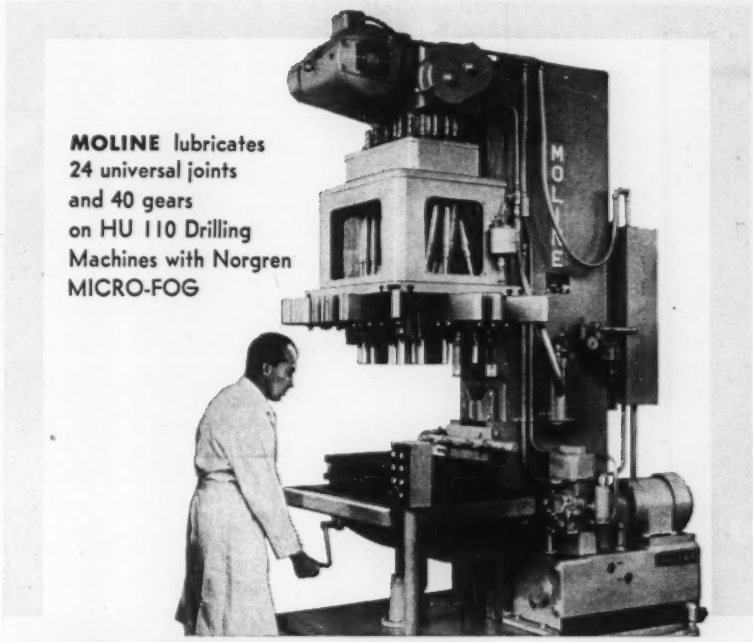
—Circle ITEM 461

High-Capacity Switch

handles 75 amp inrush current

Sealed, roller plunger, high-capacity switch, handling inrush currents to 75 amp, is made oil-tight by integral O-rings around bushing and plunger and a ring-type seal between the cover and housing. Designated BAFI-2RQN8, the switch includes an actuator that is field adjustable through 360 deg to allow operation from any direction. It is available with either right hand or left hand actuator positions. UL rating: 20 amp,

(*Continued on Page* 118)

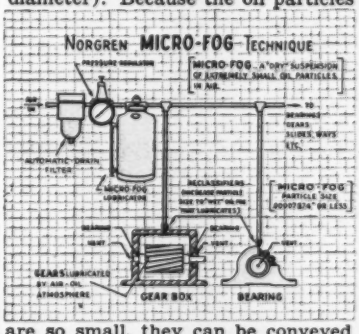


1 QT. of OIL Lubricates Machine Completely for 90 HOURS

One Norgren MICRO-FOG Lubricator automatically coats all the gears and universal joints on the Moline Drilling Machine, above, with a continuous protective film of fresh oil. Just the right amount of oil—⅓ oz. per hour—no more, no less—is applied to provide the most efficient lubrication, holding machine wear to a minimum.

What Is Norgren MICRO-FOG?

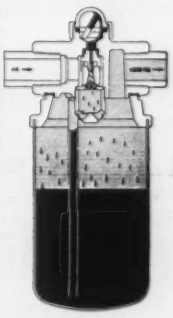
Norgren MICRO-FOG is an airborne suspension of extremely small oil particles (.00007874" or less in diameter). Because the oil particles



are so small, they can be conveyed long distances through complex piping systems without reclassifying and flooding the lines with oil—a condition formerly not possible with conventional oil-fog systems.

How Is Norgren MICRO-FOG Formed?

Air passing through the venturi section of a Norgren MICRO-FOG Lubricator creates a pressure differential that draws oil from the reservoir. The oil flows at a controlled rate into the venturi section. The venturi creates an oil fog, discharging it into the upper regions of the oil reservoir. The heavier particles of oil return to the oil supply. Only the finer particles of 2 microns (.00007874") or less are carried into the air line.



Now — MICRO-FOG For 32, 200, 300, 1000 Bearing-inch Requirements

The MICRO-FOG Lubricator on the Moline Drilling Machine, above, has the capacity to lubricate up to 200 bearing-inches. Other MICRO-FOG Units are available with lubricating capacities of 32, 300 and 1000 bearing-inches—the most complete line of aerosol lubricators. This wide range of lubricating capacities means that you can select a Norgren lubricator with exactly the right capacity for the most efficient, complete machine lubrication.

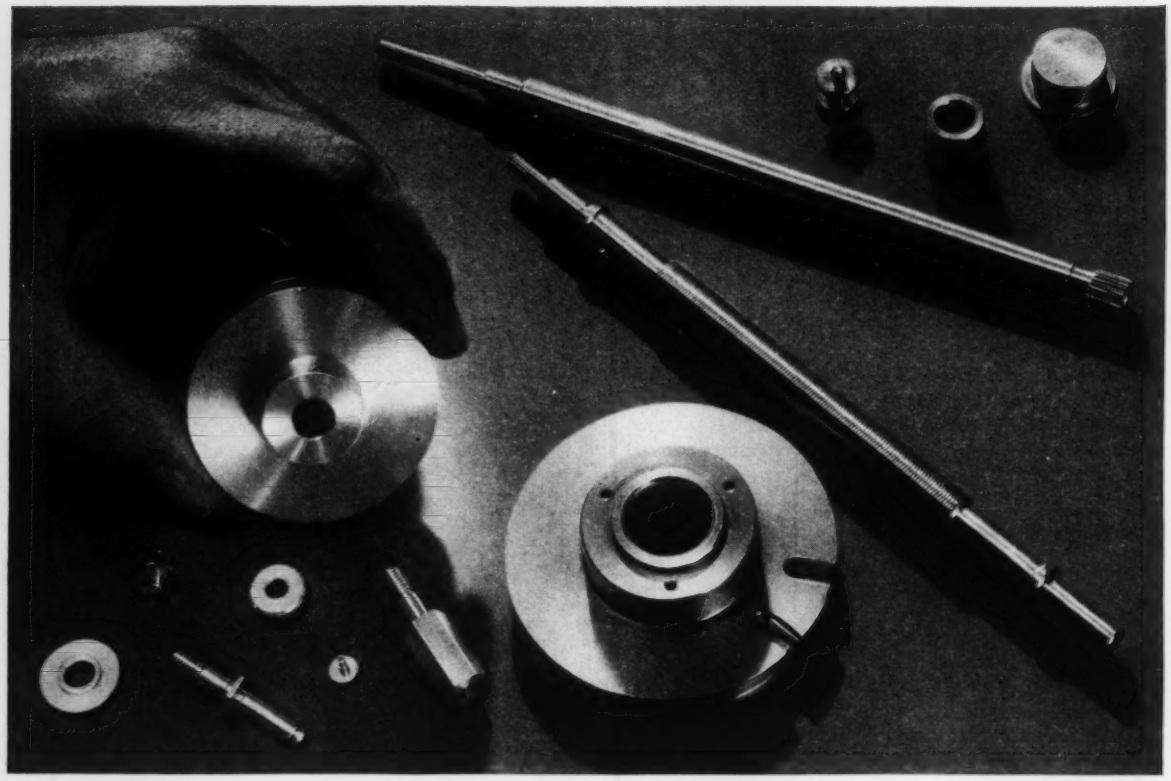
Norgren CA CO

Without obligation, learn how Norgren MICRO-FOG can simplify design, reduce costs, and improve machine performance. Call your nearby Norgren Representative listed in your telephone directory — or **WRITE THE FACTORY FOR NEW CATALOG.**

3442 SO. ELATI ST., ENGLEWOOD, COLORADO

Pioneer and Leader in Oil-Fog Lubrication Since 1930

—ITEM 546—



TYPICAL PARTS made of Alcoa Aluminum Screw Machine Stock at Dictaphone Corporation include long, slender feed screws that used to present threading problems in steel. Tolerances of three tenths are not unusual. High stock removal is routine with aluminum.

HOW DICTAPHONE CORPORATION* DESIGNS FOR SALES WITH ALCOA ALUMINUM SCREW MACHINE STOCK

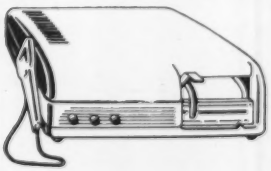
The day the dictating machine left the office and started traveling with the salesmen, surprising things happened. At Dictaphone Corporation, for example, their famous Time-Master dictating machine went on a reducing diet. From 20 pounds, this versatile machine shrank to 12.4 pounds. Aluminum screw machine parts played a major role in making the Time-Master light and portable. But, most important are the other advantages that came to Dictaphone with their switch to Alcoa® Aluminum. "Problem parts" in stainless and mild steel suddenly became routine when Alcoa Aluminum Screw Machine Stock was used. Tool and wheel life increased. Rust problems ended.

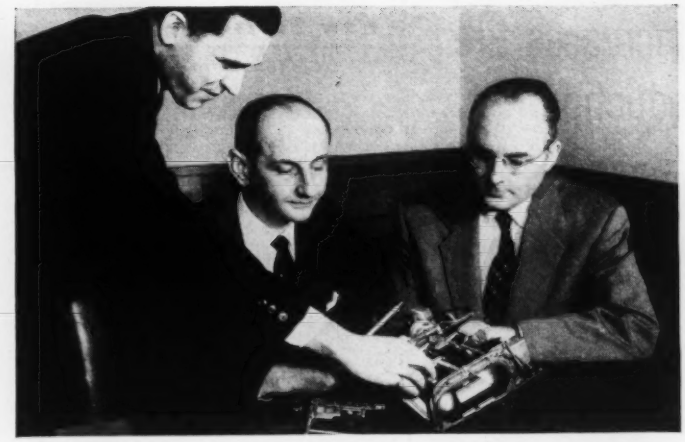
While weight reduction may not be the primary consideration for your product, the economic savings and many added advantages of aluminum can solve other problems. Low material costs (three times as many pieces from each pound), excellent machinability, ease of finishing and high resistance to corrosion will make Alcoa Aluminum Screw Machine Stock your choice for non-rusting parts. If you need high heat or electrical conductivity, aluminum has these, too.

These facts practically dictate a hard look at aluminum for the majority of your screw machine parts. To help you take that look, qualified screw machine experts are available at your local Alcoa sales office listed under "Aluminum" in your classified phone book. Aluminum Company of America, 873-G Alcoa Bldg., Pittsburgh 19, Pa.

*

Dictaphone
CORPORATION





Mr. J. S. Decker, Mr. E J. Kwantz and Mr. J. S. Kemp (left to right) discuss purchase of materials for Dictaphone's new Time-Master.

Mr. T. Chanoux (standing) talks over the design of a Time-Master part with Mr. W. G. Deschenaux.

On-the-job production conference between Mr. S. J. Redmond and Mr. J. A. Gunger.

IN PURCHASING

Mr. E. J. Kwantz, Buyer, says, "One reason we do business with Alcoa is because they study our problems and make helpful suggestions. In cases of extremely tough delivery requirements, Alcoa expedites quickly from their mills and warehouses. Availability and quality are big advantages in buying from Alcoa. We find scrap disposal easier with aluminum than with steel."

IN DESIGN

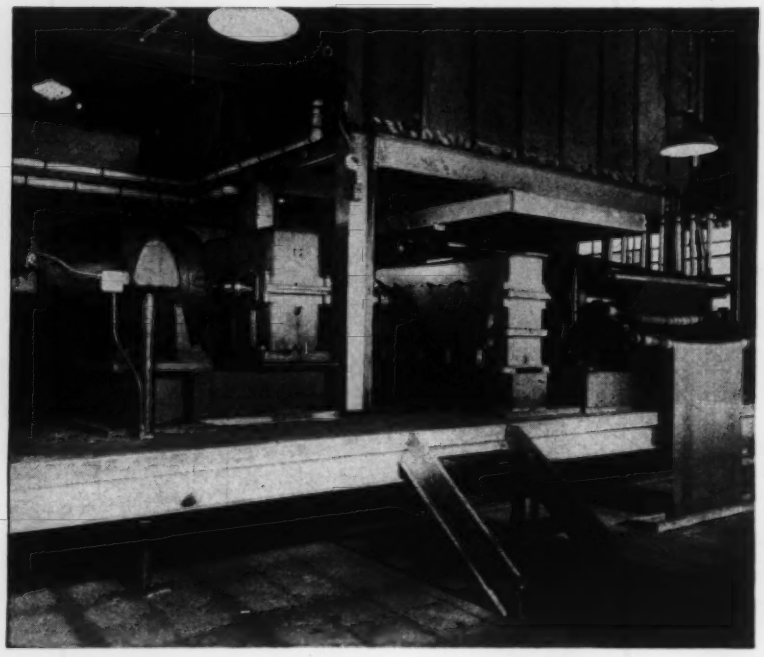
Mr. Theodore Chanoux, Chief Production Engineer, says, "Five years ago we would have been astounded at what we are doing with aluminum today. In addition to weight savings, aluminum screw machine stock helps us solve other design problems. Acme threads were impossible in stainless parts; they're simple with aluminum. Where we have to specify plating or other special finishes for ferrous parts, simple anodizing of aluminum saves us money. Some of our machined parts are bearing surfaces. Here, too, aluminum performs well."

IN PRODUCTION

Mr. Matthew Luciani, General Foreman, says, "We can chase an Acme thread on aluminum with two passes compared to six or seven with stainless steel. Tool and wheel life is longer. Lubricants used with aluminum don't get rancid and smelly. Our operators like this, and they like the fact that aluminum chips don't cut them. We make about 80 aluminum parts for the Time-Master at tremendous production savings. We run machines at top speeds and feeds. The parts don't rust in storage."

Your Guide to the Best in Aluminum Value

Lee Rubber and Tire Corp. increases tire strength... speeds production with **H & S** speed reducers!



To satisfy demand for larger, heavy-duty tires, the tire industry found that Nylon cord tension must be increased. Lee Rubber and Tire Corp. solved this problem with the help of H & S engineering. At their Conshohocken, Pa. plant two new drive units consisting of a 125 H.P. motor, an H & S LD-3600 speed reducer and a special H & S seven shaft roll drive were installed.

Now 1200 to 1920 strands of Nylon pass through the tensioning cycle at a speed of 180 fpm. As the fabric leaves the "hold back roll" run at a constant speed, it passes through a temperature of 400°F for proper heat treating. H & S powered "pull up rolls" can exert a tension from 0 to 20,000 lbs. (Older drives were limited to a tension of approximately 1500 lbs.)

The result—greatly increased tension capacity enables the Lee Rubber and Tire Corp. to "set" the Nylon cords limiting growth in tire use to 2 or 2½%. (Formerly cord growth amounted to as much as 14%). Improved tire quality and faster production were achieved.

If you have a power transmission problem, won't you let us help you? Our diversified lines assure our unbiased recommendation. Contact your H & S representative or write us today.

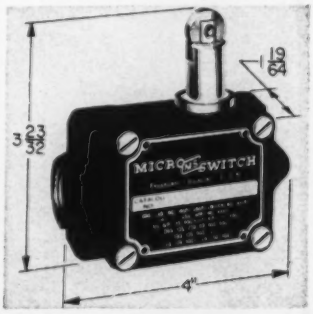
THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

Send note on Company Letterhead for complete H & S Catalog

—ITEM 548—

New Parts

(*Continued from Page* 115)



125/250 or 460 v ac; ½ amp, 125 v dc; 2 hp, 230 v ac; 10 amp, 125 v when controlling tungsten filament lamp loads on ac circuits. Contact arrangement is single-pole, double-throw. **Minneapolis-Honeywell Regulator Co.,** Micro Switch Div., Freeport, Ill.

—Circle ITEM 462

Self-Aligning Bearings

take high radial and thrust loads

These self-aligning plain spherical bearings for general industrial use reduce lost motion in linkages and withstand excessive vibration. Incorporating one-piece ball and one-piece race construction, they take high radial and axial thrust loads and offer long bearing life. Standard series, SCB, and narrow series,

SCBN, bearings are available in bores from 3/16 to 1⅞ in., with static radial load capacities from 3000 to 152,700 lb. **Southwest Products Co.,** 1705 S. Mountain Ave., Duarte, Calif.

—Circle ITEM 463

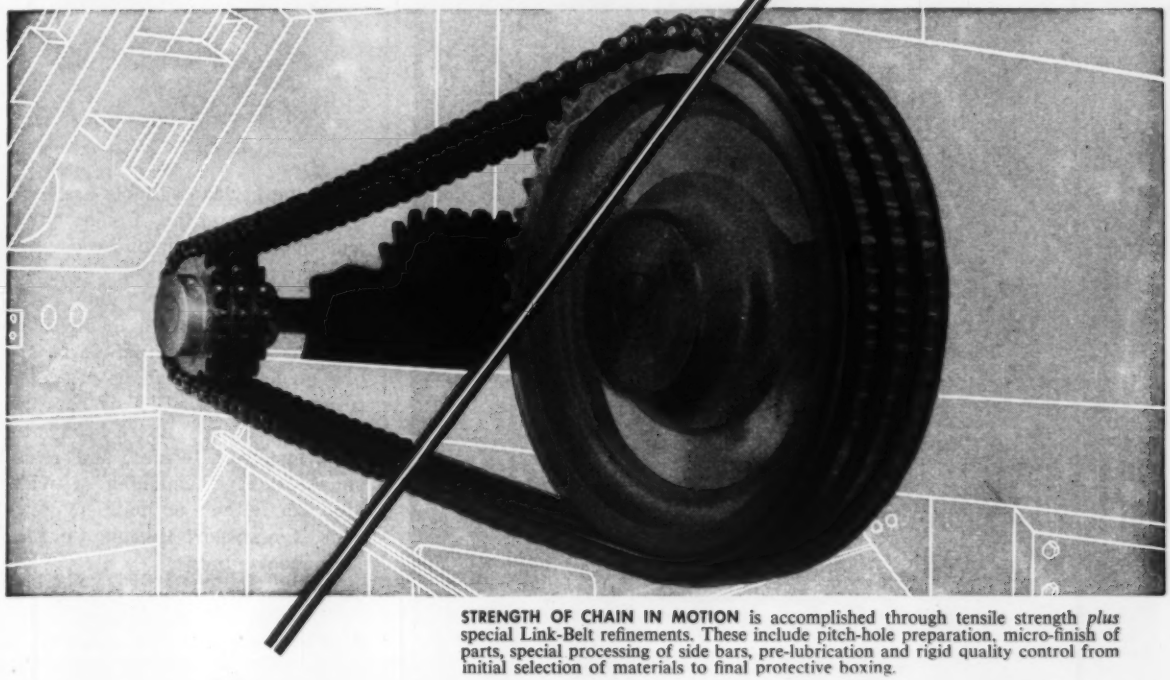
Hydraulic Cylinders

have low friction, long packing life

Line of hydraulic cylinders, identified as Super-Matic, includes seven bore sizes from 1½ to 6 in. Maximum stroke is 72 in., and

Not just static strength, but . . .

RESISTANCE TO TENSILE STRESS is achieved by use of properly heat-treated, accurately-machined side bars made of premium steel and fitted with properly-hardened pins, bushings and rollers. But to resist *operational* stresses, additional controls over dimensional accuracy, uniformity and roller resiliency are essential.



STRENGTH OF CHAIN IN MOTION is accomplished through tensile strength *plus* special Link-Belt refinements. These include pitch-hole preparation, micro-finish of parts, special processing of side bars, pre-lubrication and rigid quality control from initial selection of materials to final protective boxing.

dynamic strength

assures longer work-life for LINK-BELT Roller Chain

IN addition to known tensile loads, roller chain in motion is frequently subject to other operating stresses. Engagement with sprockets . . . shock of starting loads . . . centrifugal loads—there are many similar stresses.

Link-Belt's solution: greater dynamic strength, achieved through design, manufacturing and processing "extras" . . . plus a combination of other important refinements. On your equipment, it's a significant contribution to quality . . . provides more efficient performance and long life measurably beyond ordinary roller chain.

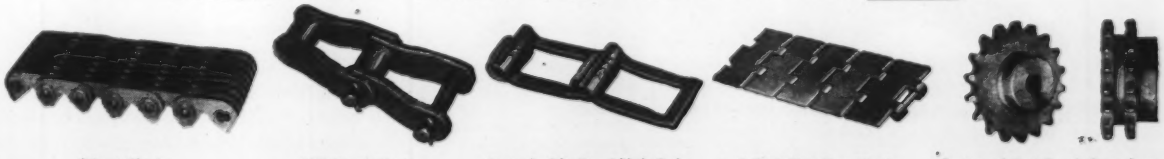
For wide design flexibility, Link-Belt roller chain covers the range of single and multiple widths—¼ through 3-in. standard pitch and 1 through 3-in. double pitch with sprockets of corresponding sizes. Ask your Link-Belt office for a copy of 148-page Data Book 2457.

LINK-BELT

ROLLER CHAIN & SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.187

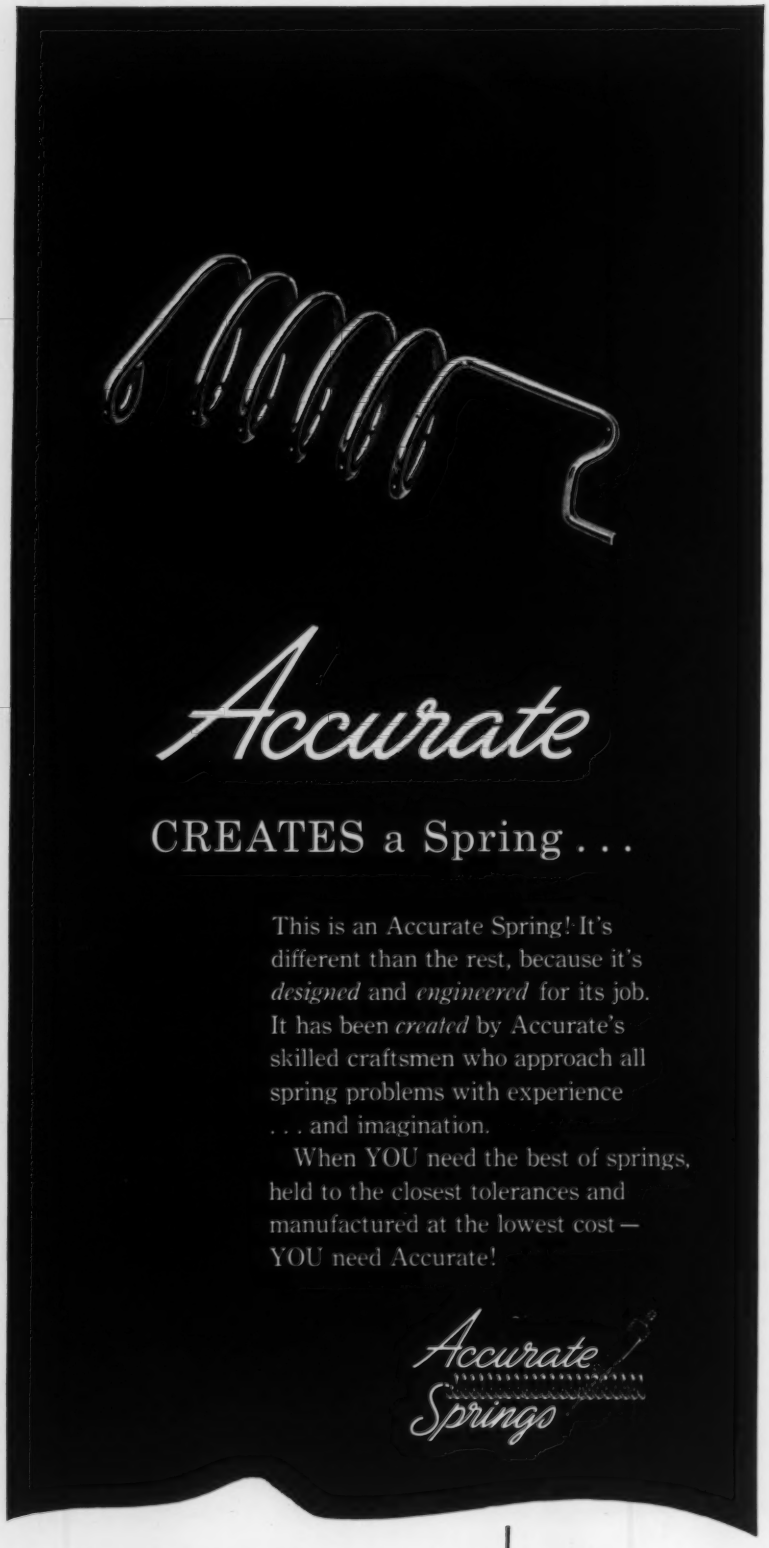
Looking for the BEST chain for a specific need? LINK-BELT makes the complete line



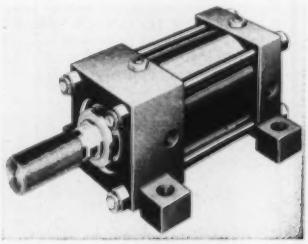
Silent Chain | LXS Steel Chain | Detachable Steel Link-Belt | S-815 Flat-Top Chain | Cast and Cut-Tooth Sprockets

—ITEM 549—

For More Information Circle Item Number on Yellow Card—page 19


Accurate
CREATES a Spring . . .
This is an Accurate Spring! It's different than the rest, because it's *designed* and *engineered* for its job. It has been *created* by Accurate's skilled craftsmen who approach all spring problems with experience . . . and imagination.
When YOU need the best of springs, held to the closest tolerances and manufactured at the lowest cost — YOU need Accurate!
Accurate Springs
ACCURATE SPRING MANUFACTURING COMPANY
3824 West Lake Street • Chicago 24, Illinois
SPRINGS
WIRE FORMS
STAMPINGS

New Parts



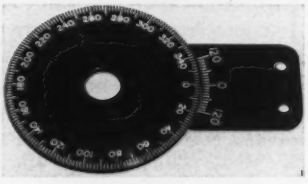
mounting styles available are foot, trunnion, centerline, flange, pivot and manifold. Piston rods are highly polished steel, ensuring minimum friction and long packing life. Hard-drawn cylinder tubes are corrosion resistant; ports are unobstructed and can be relocated to any 90-deg position by rotating cylinder covers. Extra-heavy tie rods maintain tension and resist shock loads. Cushioning is available for either or both cylinder ends. **Logansport Machine Co. Inc.,** Logansport, Ind.

—Circle ITEM 464

Dial and Vernier Set

can be read to accuracy of 6 min

Precision-engraved disk dial and vernier sets are available in four diameters from 1½ to 4 in. Made of black anodized aluminum with white filled engraving, standard



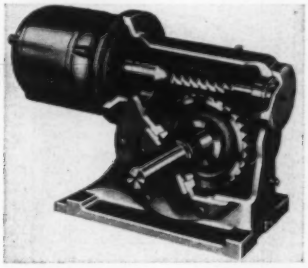
units are marked in 1-deg steps from 0 to 360 deg. Accurate readings can be made to 6 min. Stainless-steel hubs, in a wide range of bore sizes, are also available. **PIC Design Corp.,** 160 Atlantic Ave., Lynbrook, L. I., N. Y.

—Circle ITEM 465

Right-Angle Gearmotors

single-worm units have high efficiency and power ratings

Available in ratings from ½ to 30 hp, for ac or dc service, line of right-angle single-worm reduction gearmotors is offered in a wide



variety of motor types and enclosures. Well-proportioned worm and gear sizes give high overall efficiencies, high output powers and high torque. Worms, integral with shafts, are hardened alloy steel and threads are precision ground. Oil seals between motor and gear and on the output shaft prevent escape of oil or contamination of lubricant. **Elliott Co.**, Jeannette, Pa.

—Circle ITEM 466

Subminiature Potentiometer

is sealed against extreme environmental conditions

Sealed subminiature potentiometer, for use under extreme environmental conditions, meets or exceeds military humidity specification MIL-E-5272A. It is furnished with a wirewound resistance element, will operate at 135 C, and will dissipate 0.4 w at 50 C. It is screw driver adjustable over

twenty five turns, and has a self-locking shaft for stable settings. Designated Model 230, potentiometer will withstand severe shock, vibration, acceleration, sand and dust. **Bourns Laboratories,** 6135 Magnolia Ave., Riverside, Calif.

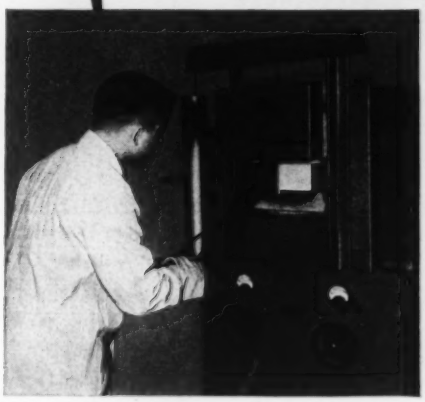
—Circle ITEM 467

Stop Nut

has self-locking collar

This stop nut is equipped with a black, resilient, nonmetallic collar which provides positive locking action of the nut in any position on

Research Results Speak Louder than Words . . .



CHIEF SANDUSKY

FERROUS AND NON-FERROUS CENTRIFUGALLY CAST SLEEVES, ROLLS, LINERS, TUBES, RETORTS, CHUTES, RINGS, BUSHINGS, BEARINGS, ETC.

The success of a centrifugal casting is often determined long before the metal is melted and the casting formed. At Chief Sandusky, it starts in the research laboratories where experienced technicians are continually searching to improve existing methods and develop new ones to meet your specialized needs.

Each casting is then quality controlled through every step of the production process. The result of this supporting and preceding control is a finer, closer grained product which resists heat, corrosion, and abrasion.

Whatever your needs in ferrous and non-ferrous centrifugal castings—or in the way of technical aid or information, call on Chief Sandusky . . . continual leader in its field, continually improving its service to you.

C. M. Lovsted & Co., Seattle, Wash. • Tynes Bros., Birmingham Ala. • Cordes Bros., San Francisco and Wilmington, Calif.

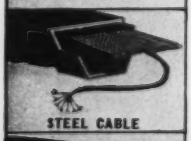
Chief SANDUSKY CENTRIFUGAL CASTINGS

FERROUS AND NON-FERROUS

SANDUSKY FOUNDRY AND MACHINE CO., Sandusky, Ohio

—ITEM 551—

Mor-Grip v-belts



Maurey *engineers* v-drives for every situation; the "stop and go" spurts of refrigeration drives; the pulsating, high torque loads of rock crushing; the smooth, steady-pull of textile drives... for short centers, and wide range of speed ratios. Maurey V-drive equipment has proved its value since 1917, improving the performance, and increasing the sales of thousands of products. Maurey delivers pulleys, belts and accessories *quickly* from complete stocks. Whether you are designing a new v-drive or improving an old one, contact Maurey. Call your local Maurey Distributor, or write direct.

Request These Catalogs

CATALOG V-55

CATALOG MVD-56

CATALOG F-10

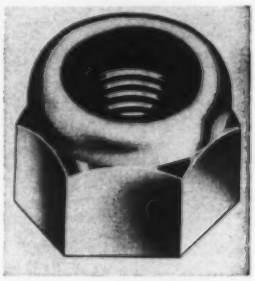
MAUREY-MATIC CATALOG

Pulleys, Sheaves V-Drive Accessories

maurey manufacturing corp.

2903-27 SO. WABASH AVE., CHICAGO 16, ILL.

New Parts



the screw, whether or not it is seated. Manufactured of steel, aluminum, brass and stainless steel, the nut can be reused many times due to the resiliency of the black locking insert. It has application in all industries such as outdoor furniture, automotive, electronic, power tools and appliances, etc., where a self-locking nut is required. **Jacobson Nut Mfg. Corp.**, Box 177, Kenilworth, N. J.

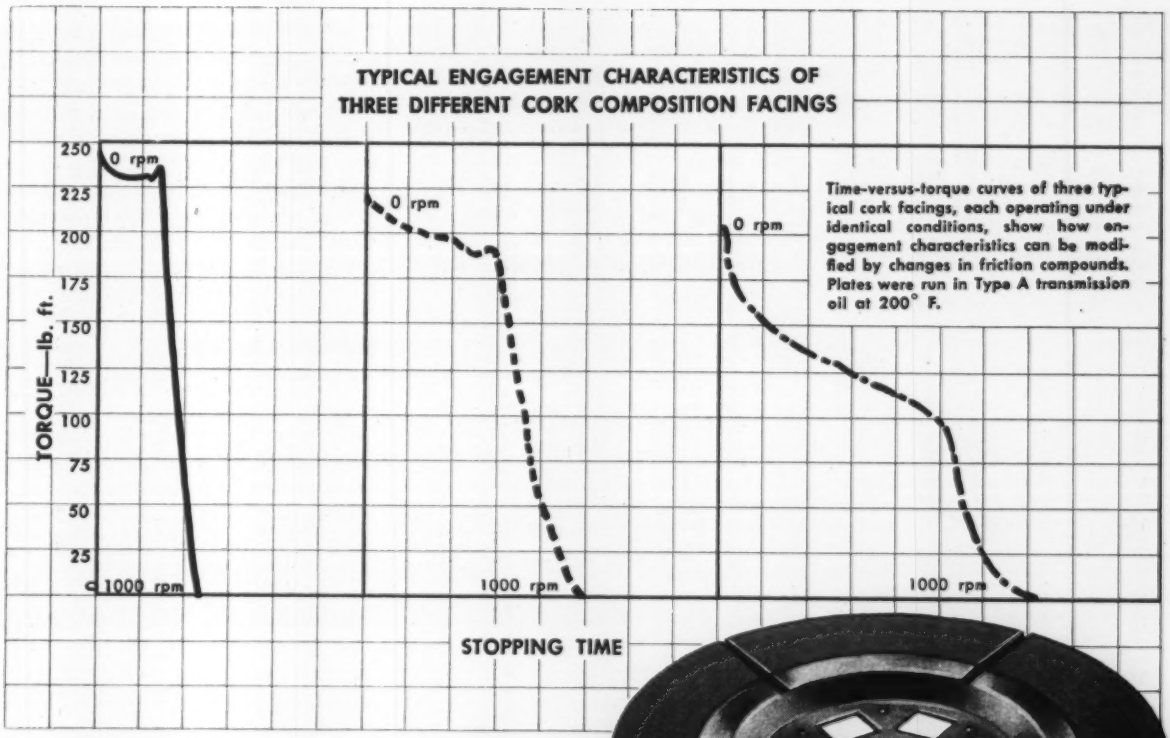
—Circle ITEM 468

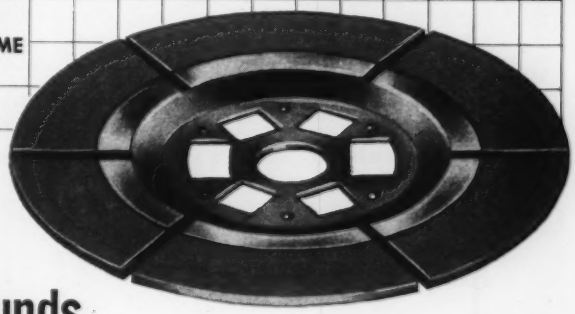
Thyratron Grid Control

gives killowatt output on less than milliwatt input

Packaged thyratron grid control unit gives proportional control of 60-cycle, single-phase half or full-wave thyratron outputs up to several kilowatts. Level of dc input signal is less than 1 milliwatt. Four isolated dc control windings provide control in accordance with several independent signals. Comprising a sensitive phase-shifting

network of rugged hermetically sealed static components, the unit gives a linear proportional phase shift of 180 deg with a small dc control signal. It is failsafe and no grid bias is required to ensure thyratron cutoff when the control signal is removed. The controller eliminates all control tubes in feedback circuits for voltage reg-





CORK CLUTCH FACINGS:

How changes in cork compounds help you control engagement characteristics

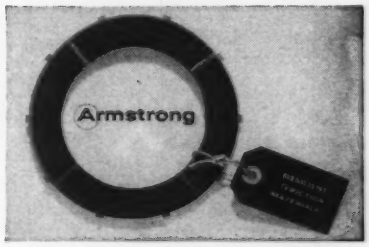
A unique design advantage of cork facings in wet clutches is that engagement characteristics can be widely modified by controlled changes in the cork compound.

For example, you can specify an engagement that is smooth and shock-free—or one that is virtually instantaneous, depending on the needs of a particular design.

The unusual versatility of cork compounds is the result of skillful compounding of cork with a variety of rubbers and resins. For example, by varying the size of the cork particles, the kind and amount of binder, or the density of the composition, many different possible materials can be produced.

The chart above demonstrates how different performance characteristics can be obtained by such changes in the facing compound. As the curves indicate, there is a marked difference in the type of engagement, even though the three test materials were run under identical conditions.

This is typical of the wide range of operating characteristics that can be secured through careful compounding of cork friction materials. More information on this subject—along with helpful charts—is contained in the booklet offered at the right.



NEW 16-PAGE BOOKLET

For more information on the design versatility of cork-compound friction materials, send for a copy of our new booklet, "Armstrong Resilient Friction Materials." It's free to industrial users. Write today to Armstrong Cork Company, Industrial Division, 7207 Dean St., Lancaster, Pa.

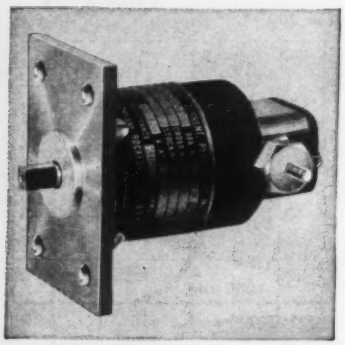
Armstrong FRICTION MATERIALS

. . . used wherever performance counts

—ITEM 553—

BARBER COLMAN **tach generators**

for accurate speed indications and rate control applications



up to 40 volts per 1000 rpm within plus or minus 0.5%

linearity over the operating range with very low slot and commutator ripple. Barber-Colman tach generators are available in three different frame sizes with maximum rated outputs up to 7000 rpm or 100 volts, whichever occurs first. Typical applications include controlling antiskid circuits for wheel braking . . . surface control systems of guided missiles . . . indication of film speed rate in aerial cameras . . . and rpm indication of variable speed drives in industrial machines, processing equipment and similar production units. Many variations of Barber-Colman tach generators are available for special applications. Send for free technical bulletin.

The complete line of Barber-Colman d-c motors

. . . includes both permanent magnet and split series types . . . in various mountings and speeds with outputs up to 1/10 hp. Ideally suited to power electro-mechanical actuators, switches, and programming devices. Also available with gearheads or blowers for special applications. Whatever your problem involving small d-c motors, let Barber-Colman Company engineers help you find the solution. Write for free Catalog F-4344-3.

Barber-Colman Company
Dept. G, 1473 Rock Street, Rockford, Illinois

—ITEM 554—

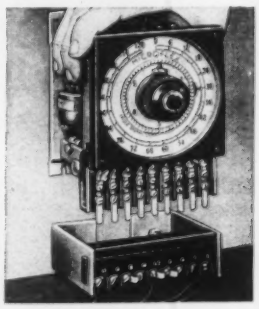
New Parts

ulated power supplies, adjustable-speed motor drives, program speed controls, servo motors, and magnetic or eddy current clutches or brakes. High sensitivity units for thermocouple signals down to 1/1000 microwatt can also be supplied. **VecTrol Engineering Inc.**, P.O. Box 1089, Stamford, Conn.

—Circle ITEM 469

Reset Timer

accurate to ±1/60 sec



Three sets of contacts are tripped open or closed after an adjustable time interval in HA4 series Microflex reset timer. Starting and resetting are electrically controlled. Threaded axle and pinion give accuracies to ±1/60 sec on a 20 sec dial. Over one hundred operating combinations are available, and time ranges from 0.3 sec to 120 hr can be provided. **Eagle Signal Corp.**, 202 20th St., Moline, Ill.

—Circle ITEM 470

Metallic Coating

primes galvanized metal for paint, lacquer or enamel

Metco metallic coating completely stops paint, lacquer, enamel or other siccative coatings from peeling off the surfaces of galvanized metal. Colorless, nonflammable and odorless, the coating may be applied by brush or a cloth saturated in the solution. It can also be used as a dip bath. Galvanized surfaces can be soldered over the finish, and no other metal wash or priming agents are required. **Solfo Paint Mfg. Co.**, Metco Div., Trenton 3, N. J.

—Circle ITEM 471

Long-Run ECONOMY in Short-Run PRODUCTION

with LAMCO PRE-TOOLED LAMINATIONS

for Developmental and Pilot-Run Production of Motors and Generators

Thousands of "special" patterns can be created without the expense and delay of special tools — at a low cost made possible by a tremendous selection of interchangeable stock tools.

Our own long experience in the engineering and production of rotating electrical gear supplements the resources of Europe's leading makers of electrical stampings.

.....Catalogs on Request

COMPANY

Box 13
300 Main Street
Stamford, Conn.
Fireside 8-7013

—ITEM 555—

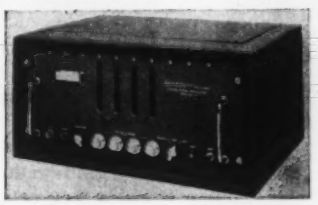
ENGINEERING DEPARTMENT

EQUIPMENT

Digital Flow Indicator

has 1 millisec to 10 sec time base

A four-digit presentation in either pounds per hour or gallons is displayed by model 5692 Digital Flow Indicator. Direct flow rate indication runs from zero to 9999 lb per hr. Time base may be varied from 1 millisec to 10 seconds, in increments of 1 millisec. The indicator operates with any impeller-type transducer, and can be easily modified for use with two or more different transducers. A complete



test feature checks the entire operation and indicates on the four banks of decimal counting units the actual time base chosen. Any discrepancy between this DCU indication and the preset counter number immediately reveals any malfunction of the system. Accuracy of the unit is ±1 count, and time-base stability is one part in 100,000, short term. Sensitivity is 5 mv at 5 cps. Binary-decimal coded output from the decimal counting units operates any standard digital recorder, inline converter and readout unit, or data reduction equipment. **Beckman Instruments Inc.**, Berkeley Div., 2200 Wright Ave., Richmond 3, Calif.

—Circle ITEM 472

Tracing Vellum

is resin treated to ensure future erasability

Improved tracing vellum, called Blutex, is treated with synthetic resins rather than oils to provide a "drier," nonbrittle working sur-

Only Twin Disc can offer you unbiased* recommendations on the application of power to industrial equipment...with Friction Clutches, Fluid Couplings, Single-Stage or Three-Stage Torque Converters

*A complete line from Twin Disc—the world's largest manufacturer of friction and fluid drives for industrial powered equipment—means unbiased recommendations on which drive is best suited to solve *your* particular problems. Friction for applications from fractional to 1050 hp—Fluid for applications from ¾ to 1,000 hp. Twin Disc Clutch Company, Racine, Wis., Hydraulic Division, Rockford, Ill.

TWIN DISC

TWIN DISC

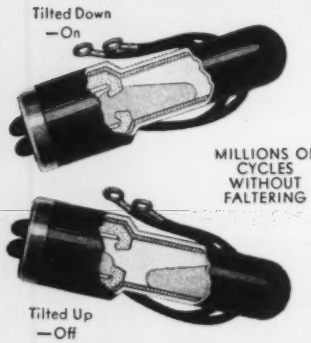
Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Tulsa

—ITEM 536—

Durakool Tilt Switches are the Life of your Automatic Controls



This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

See telephone directory for local distributor, or write.
DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.···700 WESTON RD., TORONTO 9, CANADA

Durakool ALL-STEEL MERCURY *Switches*

—ITEM 557—

Here's What DEVELOPED BY GOSHEN RUBBER means to you...

When you specify rubber products "developed by Goshen" the finest laboratory facilities and technical know-how provide the exact compound and the precision fabrication your problem demands. Consultation in design stage is always welcome.

Over 40th year 1916 • 1956

Send for FREE, 8-page brochure—tells how Goshen Rubber can help you.

Goshen Rubber Co. INC.
CUSTOM DEVELOPMENT AND FABRICATION SINCE 1916

1776 S. TENTH ST. GOSHEN, IND.

These Achievements are Goshen Rubber Exclusives

GORSYN
Synthetic rubbers (not silicones) that remain flexible in temperature ranges of —65°F to +300°F; and —20°F to +400°F.

GORLUBE
Low-friction treatment, for O-rings and parts made of natural, synthetic, and silicone rubbers.

GORBOND
Process for securely bonding rubber parts to metals of most every kind.

TETRASEAL
A precision-cut, rectangular-section static seal. Interchangeable with standard O-rings.

See our catalog in Sweet's Product Design File.

—ITEM 558—

Engineering Equipment

face of unchanging characteristics. Dryness, combined with an extra hard surface, permits faster and cleaner erasures. Transparentizing materials, specifically formulated to resist heat and aging, will not fuse with the graphite lines. Vellum is just as erasable after aging or repeated reproduction as when first used. **Frederick Post Co.**, 3650 N. Avondale Ave., Chicago 18, Ill.

—Circle ITEM 473

Photocopy Machine

handles documents to 8½ x 14 in. legal size

Verifax Signet Copier, a simplified low-cost photocopy machine, handles documents up to and including the 8½ x 14 in. legal size and can be operated under ordinary room illumination. With Verifax copy paper, up to five or more black-on-white copies are produced at a materials cost of about 2½c per copy in the letter size. Suitable papers are also available in card weight, lightweight for air mail use, and in blue and yellow for color-coding of copies or other speical applications. Translucent copy paper can be used to print intermediates or masters for use

in diazo-type printers. A standard photoflood lamp is used in the lamp housing, which is fixed well above the printing frame. The document to be copied is slipped under an adjustable glass frame with the light-sensitive (matrix) paper. An electric timer controls exposure and activation periods. **Eastman Kodak Co.**, Business Methods Sales Div., Rochester 4, N. Y.

—Circle ITEM 474

Crankshaft Machine Company uses La Salle's

NEW fatigue-proof™ STEEL BARS

to replace heat-treated alloy

- **140-150,000 PSI TENSILE**
- **MACHINES 50-100% FASTER**

FATIGUE-PROOF is specified in this automated turning machine manufactured by Crankshaft Machine Company, Jackson, Michigan.

This $60,000 machine uses FATIGUE-PROOF for a vital part. The rack that actuates the loading mechanism formerly was heat-treated alloy and is now FATIGUE-PROOF.

This is an automatic crankshaft turning machine that operates in automotive production lines. It must run dependably. The engine line can't wait for machine repairs.

The rack itself is intricate and machining it was a problem. FATIGUE-PROOF solved that, and it did so at no risk to the machine!

If you are producing parts requiring tensile strengths in the 140,000 to 150,000 p.s.i. range . . if you are interested in a steel bar that has this strength without heat treating . . if you want to trim production costs with a bar that machines faster (25% faster than annealed alloys, 50% to 100% faster than heat-treated alloys) . . if you want to eliminate the cost and inconvenience of heat treating, we invite you to send us a blueprint or detailed description of your application or, better yet, pick up your telephone and call your nearest La Salle Sales Engineer.

TEST FATIGUE-PROOF! If it appears that FATIGUE-PROOF can help improve the quality of your product or cut your production costs, your La Salle Sales Engineer will be glad to furnish you with a sample bar for testing in your own plant.

NEWLY PUBLISHED!

Ask for your copy of this 20-page booklet which gives detailed information on the remarkable new FATIGUE-PROOF . . 29 pictures, tables, charts.

La Salle STEEL CO.

1426 150TH STREET, HAMMOND, INDIANA

Manufacturers of America's Most Complete Line of Quality Cold-Finished Steel Bars

LA SALLE STEEL CO.
1426 150th Street
Hammond, Indiana

Please send me your "FATIGUE-PROOF" Bulletin.

Name_____

Title_____

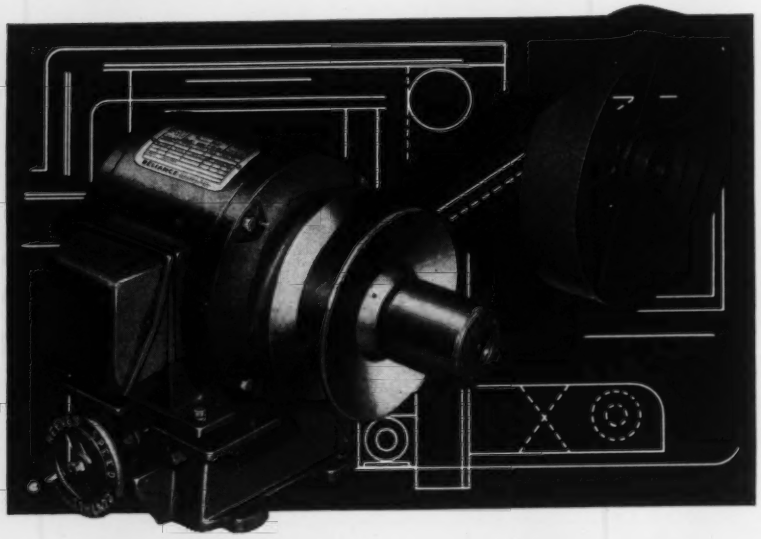
Company_____

Address_____

City_____ Zone____ State____

—ITEM 559—

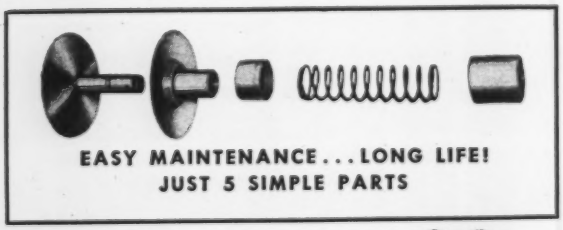
Insure machine designs against early obsolescence



REEVES

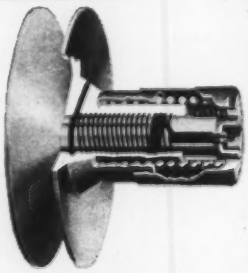
Vari-Speed Motor Pulley

A compact, low-cost variable speed drive that widens machine range . . . adds flexibility. Fourteen models for ⅛ to 15 hp; 1.75:1 to 4:1 speed ratio.



EASY MAINTENANCE . . . LONG LIFE!
JUST 5 SIMPLE PARTS

REEVES "Close-grooving" —a special lubrication system—insures free sliding disc for easy speed changes.



For bulletin complete with rating charts and dimensions, write Dept. H21a-V545.

REEVES DIVISION • COLUMBUS, INDIANA

RELIANCE ELECTRIC AND ENGINEERING CO.

—ITEM 560—

THE ENGINEER'S Library

Recent Books

Electronics in Industry, 2nd Edition. *By George M. Chute, professor of electrical engineering, University of Detroit; 497 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 postpaid.*

This book presents the basic fundamentals of industrial electronic devices and explains how these devices are used in practical circuits. Details of signal circuits are covered only as they have industrial application. Uses of vapor and gas tubes are stressed. This edition also presents recent designs of industrial controls for welding and a new chapter on simple, closed-loop circuits gives basic information on servos.

•

Reactor Handbook: Engineering. *1075 pages, 8 by 10 in., clothbound; compiled by U. S. Atomic Energy Commission; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$15.00 postpaid.*

This book is the second of six volumes prepared by the Atomic Energy Commission for scientists and engineers working with nuclear energy. It covers the technology of basic reactor systems applicable to power development. Three sections cover fixed-fuel systems: light and heavy-water cooled, liquid-metal cooled, and gas cooled. Three other sections cover fluid-fuel systems using aqueous fuel, liquid-metal fuel, and fused salts.

•

Reactor Handbook: Materials. *610 pages, 8 by 10 in., clothbound; compiled by U. S. Atomic Energy Commission; published by McGraw-Hill Book Co. Inc., 330 West 42nd St.,*

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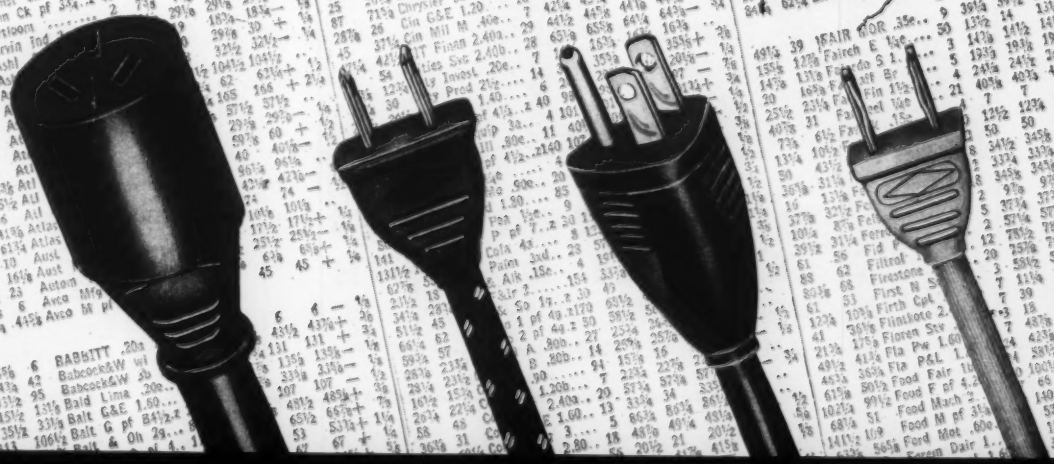


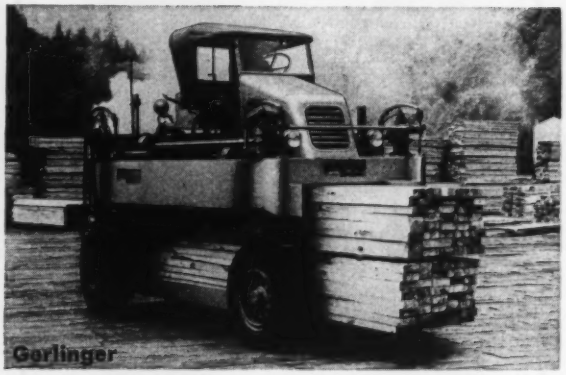
On materials handling machines used by

Hyster

Baker-Raulang

modern farmers ... by the armed forces ...

Prime Mover


Gerlinger

and by all branches of industry ...

Tamplin

BLOOD BROTHERS UNIVERSAL JOINTS are first choice!

On all kinds of materials handling equipment, dependable Blood Brothers Universals have won "first choice" reputations. This success results in part from close cooperation between our engineers and the men who design the machines . . . with the mutual goal of superior performance for the end user.

When you have a power transmission problem—large or small—contact Blood Brothers' engineers for suggestions. They'll gladly work with you . . . just write or call.

BLOOD BROTHERS MACHINE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

—ITEM 562—
For More Information Circle Item Number on Yellow Card—page 19

The Engineer's Library

New York 36, *N. Y.; available from* MACHINE DESIGN, $10.50 *postpaid.*

The third of six volumes prepared by the Atomic Energy Commission for scientists and engineers working with nuclear energy, this book covers materials used in reactor applications. For 20 classes of materials, the kinds of information given are: abundance and availability, extraction and purification, physical and chemical constants, crystallography, health hazards, handling and storage, mechanical properties, melting and casting, powder metallurgy, forming and fabrication, joining, machining, and heat treatment.

Manufacturers' Publications

Standard and Simplified Drafting Practices. 56 *pages,* 8½ *by* 11 *in., paperbound; published by and available free on letterhead request from Public Relations Dept., American Machine & Foundry Co.,* 261 *Madison Ave., New York* 16, *N. Y.*

The introduction of this booklet is a recent speech on simplified drafting by Jay H. Bergen, AMF Standards Administrator. Two sections of 44 pages following the introduction give the details of AMF drafting room practice and simplified drafting standards. The latter includes 11 rules for simplified drafting.

Government Publications

NACA Technical Series. *Each publication is* 8 *by* 10½ *in., paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics,* 1924 *F St. N.W., Washington* 25, *D. C.*

The following Technical Notes are available:

3415. **A Universal Column Formula for Load at Which Yielding Starts**—48 pages.

3578. **Influence of Large Amplitudes on Flexural Motions of Elastic Plates**—45 pages.

3636. **The Accuracy of the Substitute-Stringer Approach for Determining the Bending Frequencies of Multistringer Box Beams**—28 pages.

3647. **Investigation of the Compressive Strength and Creep Lifetime of 2024-T Aluminum-Alloy Skin-Stringer Panels at Elevated Temperatures**—29 pages.

ENGINEERS & DRAFTSMEN

WHAT'S DIFFERENT ABOUT ELECTRIC BOAT?

THE CHALLENGE OF ATOMIC POWER

As designers and builders of the world's first atomic submarines, Nautilus and Seawolf, Electric Boat has opened up a new field for development and exploration. Solving the particular problems of nuclear propulsion for submarines leads the way to wider applications of atomic propulsion.

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Electric Boat's educational program (both in the plant and at leading colleges and universities)... as well as direct supervision by the pioneers in the field... help engineers and draftsmen to learn the new techniques of nuclear design and to increase their earning power.

LIVING AS YOU LIKE IT

Electric Boat is located on Long Island Sound in Connecticut. EB employees enjoy the kind of life for which Connecticut is famous — comfortable homes, fine schools, leisure and relaxation in boating, fishing, swimming — all are part of the everyday pattern of living.

JOB STABILITY REALLY MEANS SOMETHING

You'll find another difference in working at Electric Boat. During the past 35 years of fluctuating employment opportunities, no engineers or draftsmen have been laid off. Our personnel are secure in the knowledge that their jobs are permanent.

IMMEDIATE OPENINGS FOR:

NAVAL ARCHITECTS

MECHANICAL AND ELECTRICAL ENGINEERS
with 3 to 5 years experience in the application of mechanical and electrical marine power plant equipment.

PIPING DRAFTSMEN
Minimum 2 to 3 years experience in design of steam, condensate, air, water, ventilation, hydraulic systems or reactor piping systems. Marine power plant or chemical process experience desirable.

MECHANICAL DRAFTSMEN
Minimum 2 to 3 years experience in design of hydraulic components, gear and link mechanisms, castings, weldments and special valves.

ELECTRICAL AND/OR MECHANICAL ENGINEERS
for basic design using analog computers, with respect to control systems, motor control circuits, power plant, speed and voltage regulators or fluid flow and thermodynamics. Familiarity with engine room and reactor plant electrical systems and controls desirable.

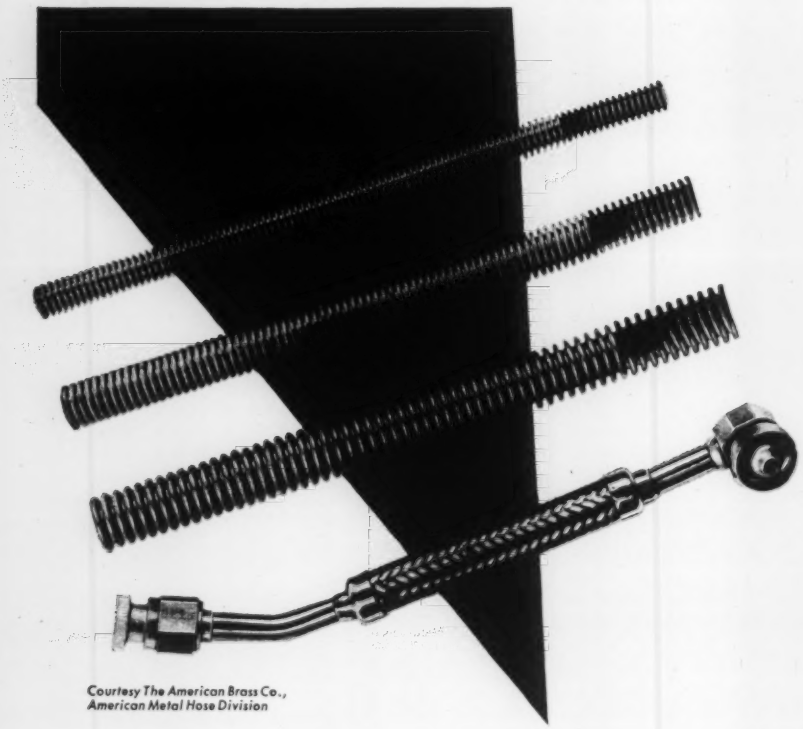
STRUCTURAL DRAFTSMEN
For design and detail of structures and foundations associated with nuclear powered submarines.

ELECTRICAL DRAFTSMEN
Minimum 2 to 3 years experience in the development of electrical plans for A.C. and D.C. power, lighting, interior communications, control and electronics systems.

If you have the required experience, and if you seek the opportunity to broaden your experience and a chance to do more creative work, Electric Boat is a wise choice. Send resumes, including salary requirements, to Peter Carpenter.

ELECTRIC BOAT
Division of General Dynamics Corporation
GROTON, CONNECTICUT

—ITEM 563—



Courtesy The American Brass Co., American Metal Hose Division

IS STRESS YOUR PROBLEM?

Flexible metal hose must withstand high temperatures, pressures, corrosion and vibration. For this reason many important companies select BISHOP stainless steel thin wall tubing for their flexible metal hoses.

You, too, can depend on BISHOP mechanical tubing to withstand the tortures of today's pressures in sizes from .008" to 1.000" O.D. with a .003 to .083" wall thickness.

CAPILLARY, MECHANICAL, HYPODERMIC and AIRCRAFT

Stainless Steel Tubing —seamless and welded and drawn (.008" to 1.000" O.D.)

Flanged, Flared, Milled, Slotted, Swaged, Threaded NICKEL & NICKEL ALLOY TUBING (up to .625" O.D.)

Send us your specifications for prompt quotations.

J. BISHOP & CO. Platinum Works

Stainless Steel Products Division, Malvern, Pa.

Established 1842

New Machines

Materials Handling

Die Handler: Designed to be mounted on a heavy-duty industrial truck, the die handler loads and removes dies weighing up to 6000 lb from inclined presses. Table can be rotated horizontally 180 deg, permitting loading and unloading from any angle of approach. The table also tilts to permit positioning and retrieving dies in presses inclined up to 45 deg. Controlled by a portable pushbutton panel, the unit operates from the truck's hydraulic system. The die handler can be mounted or dismounted quickly from the truck. *Yale & Towne Mfg. Co., Automatic Transportation Co. Div., Chicago.*

Fork Lift Truck: W-40 two-ton high-lift truck is equipped with power steering. Standard lift heights are 90 or 108 in.; rigid mast tilts 10 deg backward and 3 to 5 deg forward. Driver's seat is in the center of the truck to assure good visibility on both sides and to permit mounting from either side. All dials are located in a panel directly in front of the driver, and control levers are conveniently located close to the steering wheel. Steering column is supported by the instrument panel. Speed of travel is up to 8 mph, two speeds forward and reverse. The engine is a four-cylinder, L-head type with 140 cu in. displacement. It develops 40 bhp. Wide tires, front and rear, provide good traction. *Knickerbocker Co., Truck-Man Div., Jackson, Mich.*

Metalworking

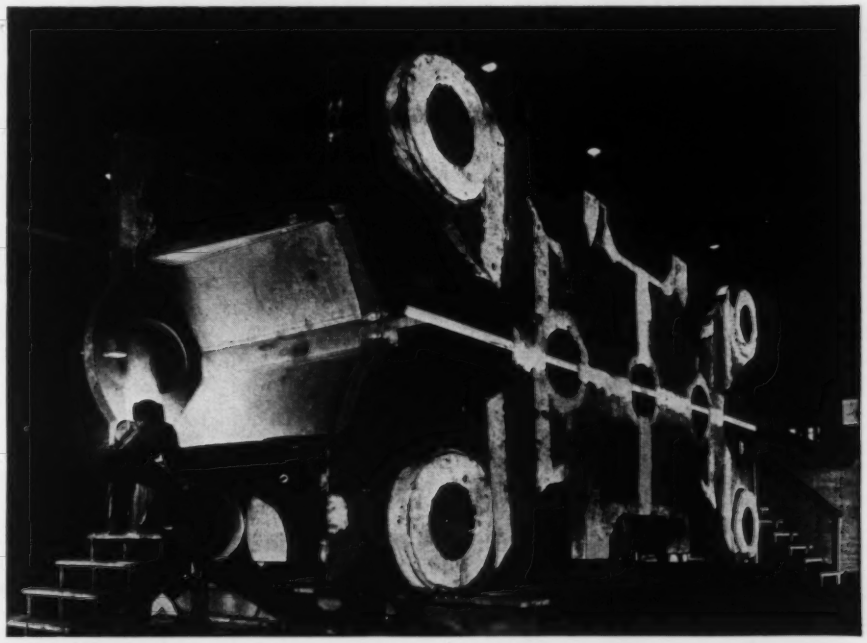
Roller-Leveller: Model 11-F machine is used for straightening sheet stock, coil stock, producing cut length flat sheet from coil, and work annealing deep drawing steel. It flattens mild steel, hard-tempered steel, stainless steel, aluminum, brass or copper in widths up to 42 in. and in gages from 0.020 to 0.093. The machine operates at

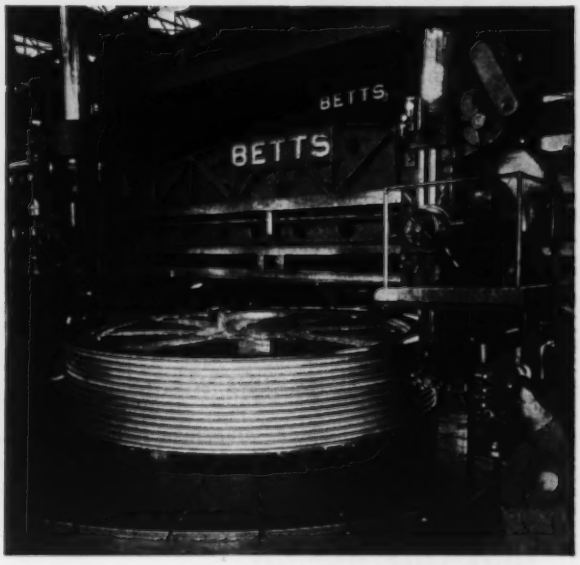
—ITEM 564—
For More Information Circle Item Number on Yellow Card—page 19

What Type Weldments Do You Need?

Heavy

168 tons is the weight of this crown for an 8,000-ton hydraulic press. It consists of rolled plates and castings, joined by welding, and measures 12 ft x 29 ft x 9½ ft. Our shop facilities include 100-ton cranes, giant stress-relieving furnaces, a 6,000-ton plate-bending press and high-capacity X-ray machines. We can handle weldments as large as can be shipped.





Accurate Precision was the watchword in fabricating 288 octagonal blocks. Each consists of twelve ½-in. plates separated by insulating fibre. Bethlehem engineers assembled them to form the mammoth magnet for the world's largest atom smasher. Flame-cutting, assembling by welding, and other steps in fabrication required an unusual degree of accuracy.

Composite Forged and rolled-plate components were used in fabricating this 37-ton counterweight sheave. Composite weldments, including cast, forged, structural and rolled-plate parts, are readily handled in our Weldment Shop. And we can finish-machine the biggest, toughest jobs that come along. Bethlehem crews will handle field erection, if desired.

For further information about custom weldments, please call or write to the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

—ITEM 565—

HELPFUL DESIGN INFORMATION

The articles listed below have been reprinted from MACHINE DESIGN and are now available at no charge from the Reader Service Department.

1 WHEN TO SPECIFY SPECIAL MOTORS
by Robert C. Dobbin
The factors in deciding whether a modified standard or custom-designed motor is practical and economical for a particular product design. (20 pages)

2 GEOMETRIC TOLERANCES
by H. Blye
A plan for their simplified specification on drawings, and a recommended schedule of standard and special-quality limits. (10 pages)

3 3-D MECHANISMS
by F. R. Erskine Crossley & Frederic W. Keator
Discussion of basic types and characteristics, and analyses of dimensional and velocity characteristics of "conic quadric" linkages. (11 pages)

4 DESIGNING BUILT-IN LIGHTING FOR MACHINES
by Robert C. Rodgers
Pertinent background data and an outline of specific steps in the process of designing for the most economical, practical and effective built-in lighting. (16 pages)

5 MOTOR CIRCUIT PROTECTION
by G. W. Heumann
Selection of conductors—Protection against overloads—Short-circuit protection—and Safety in hazardous atmospheres. (16 pages)

6 GEAR DIFFERENTIALS
by G. W. Michalec
Definition, analysis, types and applications of gear differentials . . . Common designs, functioning errors, testing, practical design factors and commercially available units. (19 pages)

7 GEAR LUBRICATION
by S. Kyropoulos
A summary of the whole area of gear lubrication, with special emphasis on lubrication of higher capacity types of gearing and on unusual operating conditions. (15 pages)

8 DESIGNING ALUMINUM FORGINGS
by A. E. Favre
A review of designing aluminum forgings for heavier presses—alloy selection, draft angles, fillet radii, parting line location and tolerances. (9 pages)

MACHINE DESIGN
READER SERVICE

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New Machines

a standard speed of 56 fpm. Sprocket change increases or decreases standard speed. The unit is powered by a gear-head, single-speed motor readily accessible for maintenance. A variable speed drive is also available. Manually controlled reversing drum switch and motor cut-out switch with thermal overload protection are standard equipment. The straightening and feed rolls are hardened, ground, chrome-plated alloy steel. All rolls except the top feed roll are driven by a closed gear box. Bronze bearings in the gear box are lubricated by oil retained in the box. Other working parts are lubricated through pressure grease fittings. *F. A. Woehr Machine Co., Rochester, N. Y.*

Power Shear: Heavy-duty 24-in. shear performs straight and angle shearing, sequence shearing, slitting, notching, blanking and accurate duplication of straight-side parts without dies. It has a blade length of 24 in., throat depth of 7½ in. and capacity up to ⅛-in. in mild steel, 3/32-in. in stainless steel and 7/32-in. in duraluminum. The shear operates at speeds up to 120 strokes per minute. Table is equipped with tapped holes for accurate set-up of protractors, clamps and cutting guides. For conventional shearing, the unit has a front-operated back gage. Design incorporates counter thrust slide for burr-free cutting, solenoid-operated safety clutch, adjustable hold-down fingers with molded neoprene cups, work chute discharge to front or rear, foot control switch and machine-mounted pushbuttons, selective operation for continuous or single-stroke cutting, fully enclosed drive and fluorescent light gage which illuminates the table and provides for shearing to a scribed line. The shear has a 1½ hp drive motor and V-belt drive. *Lodge & Shipley Co., Cincinnati.*

Plant Equipment

Mobile Access Lifts: Available in six models for maximum reach from 19 to 42 ft, hydraulically-operated lifts are used indoors or out and are easily transported. They fold up to pass through doorways, narrow corridors and in and

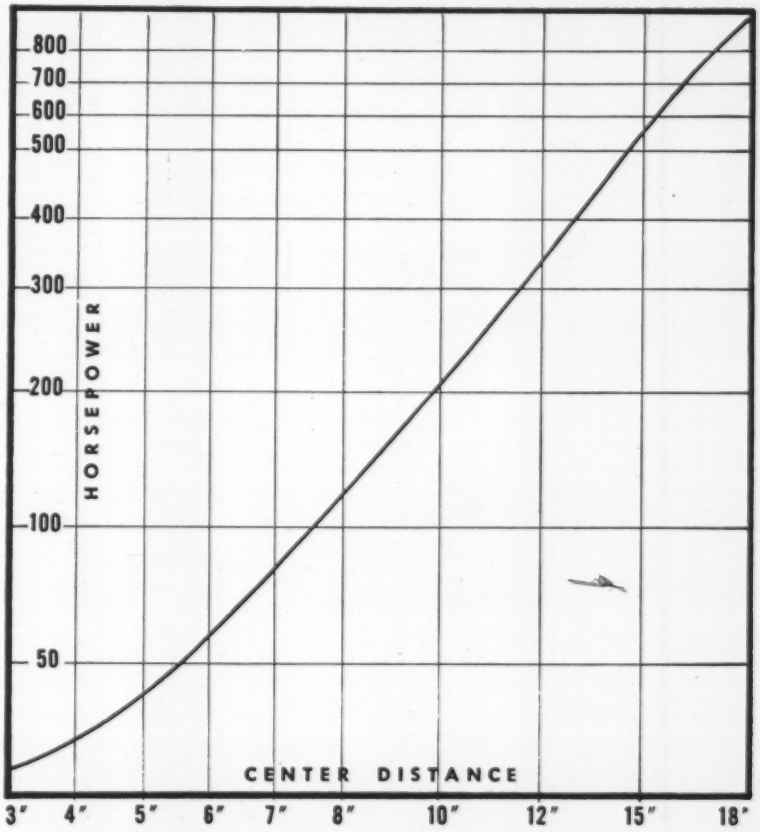
out of elevators. Maximum stability is assured by screw type leveling jacks at each corner to hold the lift in a steady, level position. Large swivel type casters permit ready mobility. A ladder provides access to the platform in the down position. Complete control for raising, stopping and lowering is obtained by means of a push-button control located on the platform guardrail. The platform is 2 ft 3 in. square and has 3-ft guardrails. It can be rotated through 360 deg, and supports 350 lb. All models have a 110-v, 60-cycle, single-phase pump motor plus hand-operated pump for use where electric power is not available or when power shut-down occurs. *Ballymore Co., Wayne, Pa.*

Vacuum Cleaner: Transferable-head, outside-bag cleaner has detachable motor to permit use of the unit as a strap-back vacuum or blower. The vacuum has large air volume and high speed. Optional equipment available includes a 55-gal tank and four-wheel, ball-bearing dolly. *Hild Floor Machine Co. Inc., Chicago.*

Testing and Inspection

Relaxation Tester: Automatic relaxation tester maintains a fixed extension or strain when testing at elevated temperatures. Specimen is inserted in an electric circular testing furnace mounted between the crossheads. Furnace can be used for testing at any temperature up to 1800 to 2000 F. Temperatures are controlled by a separate unit adjacent to the machine. Predetermined extension in in. per in. is selected and the machine is started at the desired loading speed. Load is applied to the specimen until the fixed extension is attained. As the specimen strains further under increasing temperature and load, the amount of load is automatically reduced to maintain fixed extension. All variations of the test are recorded automatically by an XY electronic recorder mounted in the face of the machine. Controls for all phases of the test are also mounted in the face of the machine. *Tinius Olsen Testing Machine Co., Willow Grove, Pa.*

"DO-IT-YOURSELF"



Prove the difference in worm gear speed reducers yourself. Here's how . . .

. . On this chart we've plotted the mechanical horsepower capacity of Cone-Drive worm gear speed reducers against their center distances. Ratings are for Class I Service with a 5:1 reduction and an input speed of 1750 rpm.

All you have to do is plot the corresponding ratings for the speed reducers you're now using or planning to use. We think you'll be surprised at the results.*

For details on Cone-Drive gearing's double-enveloping design and specifications, ask for Bulletin 600C. We'll send it to you immediately without obligation.

*If you're too busy to "Do-it-yourself", Cone-Drive representatives will be glad to show you filled-in charts.

CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

—ITEM 566—

ARE YOU CHANGING DESIGN ON AIR OPERATED MACHINES TO CUT COST AND IMPROVE OPERATION?

$18.50 List Price*

*$18.50 is the list price for the ¼ inch port size and $19.50 for the ⅜ inch, less the usual quantity and trade discounts.

HERE'S BOTH LOWER COST AND BETTER CONTROL IN THE 'SHEAR-SEAL' 4-WAY AIR VALVE (250 P.S.I.)

You need no oiler and filter ahead of this valve because it's made entirely of corrosion resistant materials and moisture won't harm it.

It operates freely on dry, unlubricated air, and dirt or pipe scale in the line cannot damage the valve or hold it open because of the unique "Shear-Seal" design.

The leak-proof holding quality which does not diminish after prolonged service is perhaps the most outstanding characteristic of the wear-compensating "Shear-Seal."

The external design stresses savings through convenience of porting, any port can be the "in" port; of mounting, valve has a bracket that may be shifted or removed to make way for panel mounting; of maintenance, valve can be serviced without touching the plumbing.

Ask for bulletin A-5.

BARKSDALE VALVES

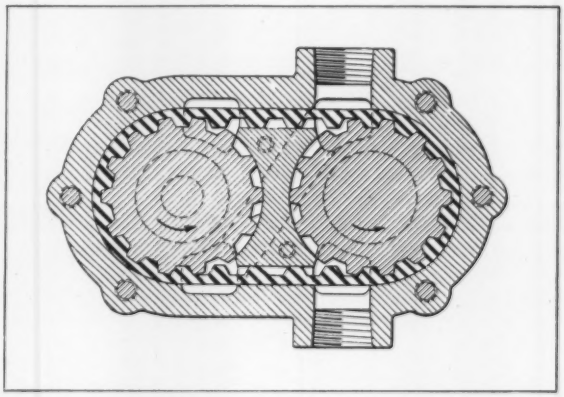
5125 Alcoa Avenue, Los Angeles 58, California

—ITEM 567—
For More Information Circle Item Number on Yellow Card—page 19

NOTEWORTHY Patents

Positive-Displacement Pump

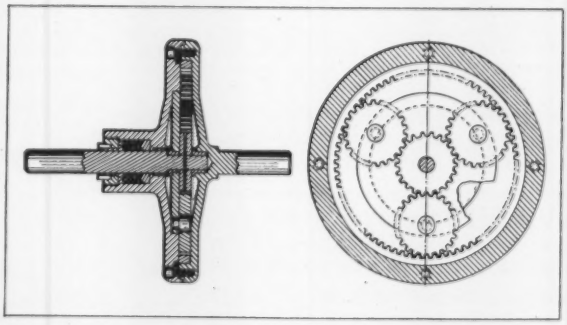
Multiple flow-transfer passages, internally connected at the pump outlet, give high flow rates in a gear type pump that operates quietly without metal-to-metal tooth contact. Applicable for pumping service in abrasive liquids and other fluids, the unit can also be used as a hydraulic motor. Fluid-



displacement gears, coupled together by a flexible toothed belt, are driven with low-contact stresses and therefore can be made of soft plastic. Design variations include use of multiple belt-coupled pump gears. *Patent* 2,745,355 *assigned to George D. Roper Corp. by Bruce H. Mosbacher.*

Torque-Converting Coupling

Within predetermined torque limits, steady-state operation of a torque converting coupling gives positive transfer of power from input to output shafts at



1:1 speed ratio. In the straight-through drive condition, rotation of a planetary gear set in the coupling is blocked by oil entrapped in meshing tooth spaces be-

SOLVES MANY REDUCER MOUNTING PROBLEMS

ONE

FOOTE BROS. NEW Mounting Supports Unit

This trademark stands for the finest industrial gears made.

Line-O-Motor

One base supports both speed reducer and motor in this simple, practical and foolproof mounting system . . . Now you can use standard N.E.M.A. motors and make change-overs in minutes—reducing both costly down-time and motor inventory.

Line-O-Power motorized drive solves many old problems . . . and opens new fields of advanced design for new applications. Available 1-75 H. P. for all Service Classes—Horizontal, Vertical, and Vertical Extended with Foot or Flange mounting—Double or Triple Reduction units available in Ratios from 5.06:1 to 238:1.

Write for your Line-O-Motor Catalog today

Better Power Transmission Through Better Gears

4545 S. WESTERN BLVD., CHICAGO 9, ILLINOIS

Department O

—ITEM 568—

For More Information Circle Item Number on Yellow Card—page 19

Save up to
40%
with ALCOA
UTILITUBE

Compare these advantages of ALCOA® UTILITUBE with the coiled tube you're now using

LOW COST—actually costs up to 40% *less* per foot than copper tube
LONG LENGTHS—available in economical lengths up to 1,000 feet
EASY WORKABILITY—bends easily, work-hardens less
HIGH FATIGUE STRENGTH—stands up well under vibration
CORROSION-RESISTANT—resists most industrial atmospheres, many gases and liquids
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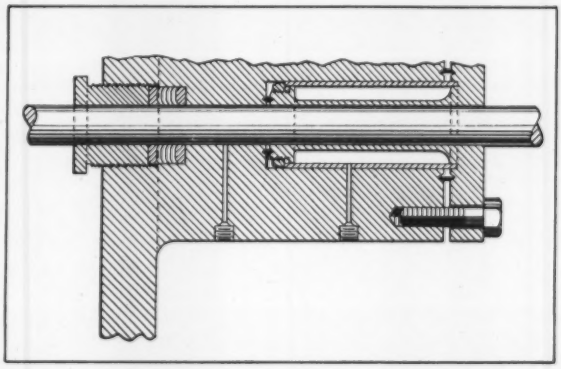
Noteworthy Patents

tween planet gears and the ring gear. Under high-torque conditions, entrapped oil is forced from the tooth spaces, permitting relative motion of the internal gearing with resulting torque multiplication. In similar manner high output torque is provided during initial acceleration and load pickup since oil has not yet been centrifugally distributed to the tooth spaces. *Patent* 2,743,628 *assigned to National Engineering Corp. by Frank L. Scharaffa.*

High-Pressure Seal

Rotating shafts entering high-pressure vessels are sealed against excessive fluid leakage at pressures to 10,000 psi by an adjustable bushing seal. Principal



sealing element is a thin-walled flexible cylinder, integral at one end with the seal cap and free to move axially on an antibuckling support at the other. Hydraulic pressure applied from an external source is ported to the annular space surrounding the thin flexible cylinder, regulating clearance and fluid leakage around the shaft without necessity for close control of manufacturing tolerances. Second external source of lubricating fluid, introduced between the flexing cylinder and the conventional gland-nut packing, leaks out between the shaft and flexing cylinder to minimize friction losses. *Patent* 2,726,883 *assigned to Standard Oil Co. by Theodore C. Taylor.*

Bellows-type pump, for service with hot or corrosive liquids, maintains complete separation between liquid and the pump mechanism. Opposing bellows pair, sealed with open ends facing central housing partition, are internally connected by a tie rod. Cyclic compression and extension of one bellows, hydraulically imposed by an integral piston pump, forces pumping action of second bellows. *Patent* 2,735,369 *assigned to Universal Oil Products Co. by William E. Turvey.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

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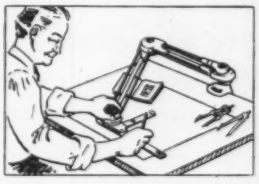

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2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

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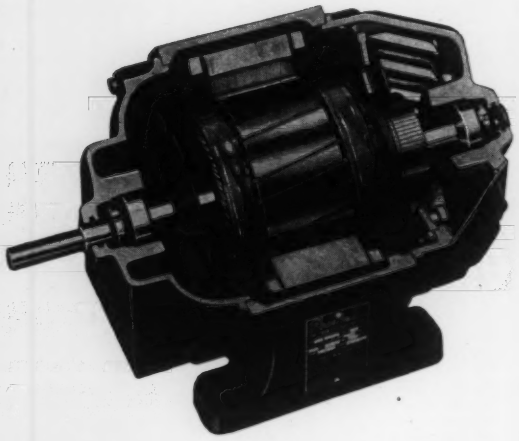

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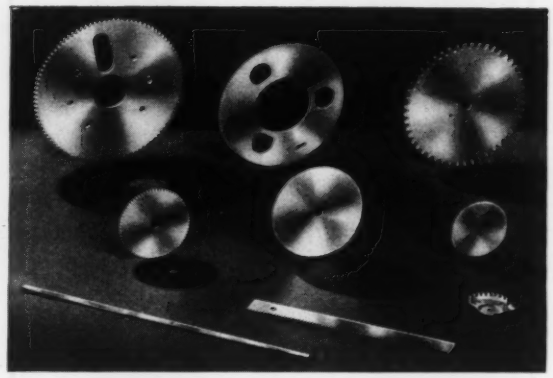

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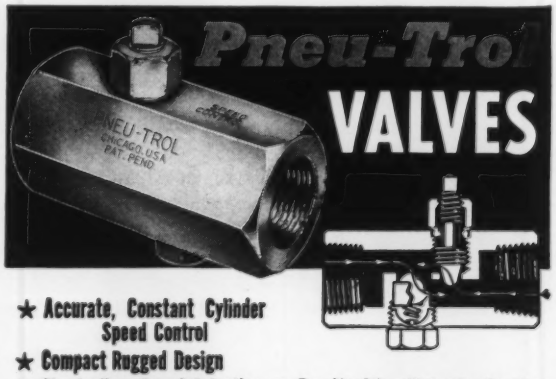

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By Mayline

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Table is produced in popular top sizes and in two base sizes. Write factory for complete information.

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Design Guide to

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- **ELECTRICAL**
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Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

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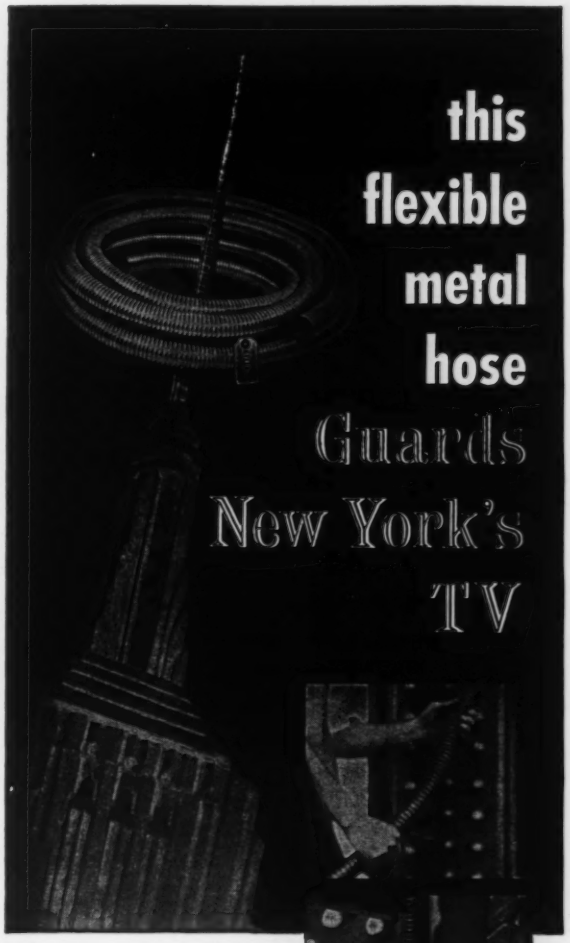

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The $1,000,000 tower atop the Empire State building was designed to usher in a new era in TV transmission and reception. Its construction required an unprecedented number of circuits to travel up a tower often of less than two feet square. The conduit, enclosing the cables, had to be extremely *flexible* to avoid splice plates, rivet heads and diagonal braces in the steel work. It had to be permanently weather tight.

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Our engineers will help solve *your* problems in weather protection . . . flexibility . . . conveying . . . controlling pressure, movement and vibration . . . correcting misalignments. Seamless and Interlocking Hose. Bronze, Steel, Stainless Steel, Monel. ⅛"-36" I.D. with proper fittings. Write for Bulletin #500. See our Catalog in Sweet's Product Design File.

JOB TESTED CERTIFIED

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—ITEM 577—

design data

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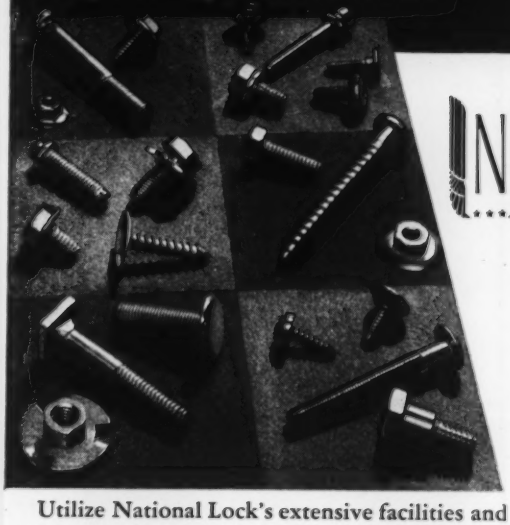

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WANTED: Product Engineer with design and production engineering background in mass-produced consumer products. This position requires an energetic man with sufficient background to initiate product part changes and deviations for cost reduction, improved performance, and stable production. He must know foundry, die casting, metal stamping and forming, and screw machine processes and be able to deal directly with suppliers in these fields. This opening is in our new Fort Wayne, Indiana plant and the Engineer will report directly to the General Manager. Please send resume of qualifying experience, previous salaries, recent photograph, references, and required salary to Personnel Manager, Magna Power Tool Corporation, Menlo Park, California.

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BPA NBP

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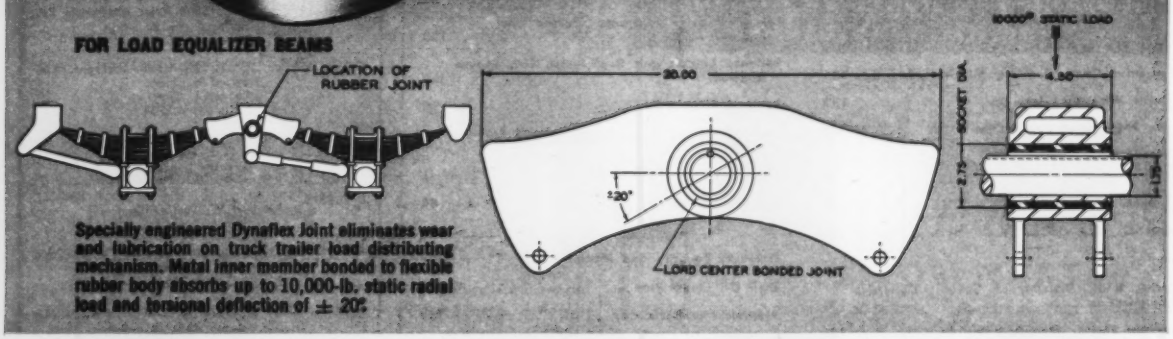
LORD DYNAFLEX® JOINT—a long-wearing, lubrication-free resilient bearing for pivots.

With LORD Dynaflex® Joints you have a new, better answer to problems on pivot joints. One that eliminates wear and lubrication . . . absorbs shock and reduces noise . . . assures mounting and alignment accuracy.

These new, high-capacity resilient bearings provide positive cushioned action—and accommodate static and dynamic radial loads encountered in heavy duty commercial vehicles, torsional deflections up to ± 30° and angular deflections up to ± 7°. Fatigue-defying flexing elements are specially compounded rubber, permanently LORD-bonded to steel members. Design is simple and compact, requires no close tolerances, and usually will fit present equipment with little or no change in mating parts. No metal rubs against metal.

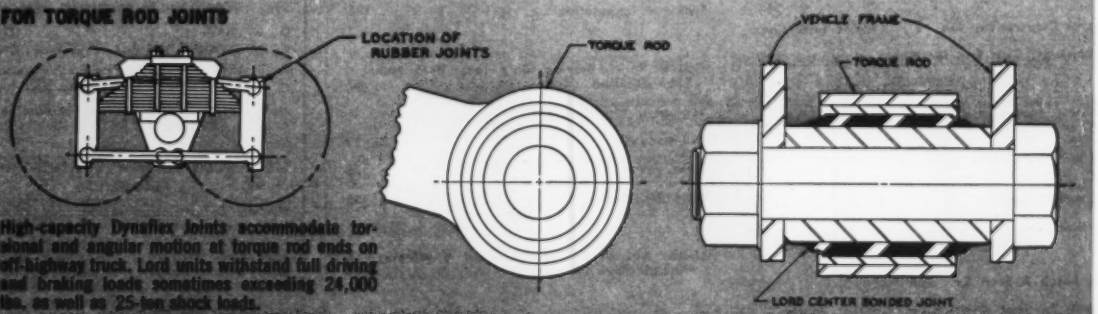
Bonded rubber Dynaflex Joints are the product of LORD development engineers who can produce special designs to solve your specific pivot point application. For further information, contact your nearest LORD Field Engineer or write the Home Office, Erie, Pa., for Bulletin No. 703.

FOR LOAD EQUALIZER BEAMS



Specially engineered Dynaflex Joint eliminates wear and lubrication on truck trailer load distributing mechanism. Metal inner member bonded to flexible rubber body absorbs up to 10,000-lb. static radial load and torsional deflection of ± 20°.

FOR TORQUE ROD JOINTS



High-capacity Dynaflex Joints accommodate torsional and angular motion at torque rod ends on off-highway truck. Lord units withstand full driving and braking loads sometimes exceeding 24,000 lbs. as well as 25-ton shock loads.

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LORD BONDED RUBBER

designers and producers of bonded rubber products since 1924

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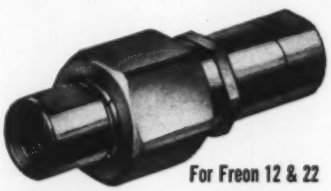
Fluid Systems That Need Frequent Disconnection

NEED AEROQUIP SELF-SEALING COUPLINGS

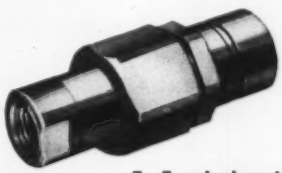


For Freon 12 & 22

Aeroquip 511017 Self-Sealing Coupling for refrigeration and air-conditioning applications makes low cost field installation possible by permitting factory charging of the units and lines of various lengths. Mates with sweat-type adapters.

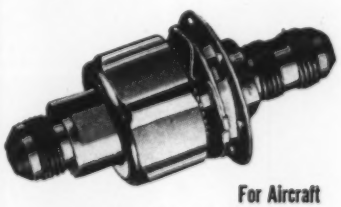
For LP Gas

Aeroquip 5102 Self-Sealing Coupling speeds recharge of LP-Gas fuel tanks on trucks, tractors. Coupling has Acme and P.O.L. threads to fit any recharge line. Absolutely no leakage of fuel upon connecting or disconnecting.



For Farm Implements

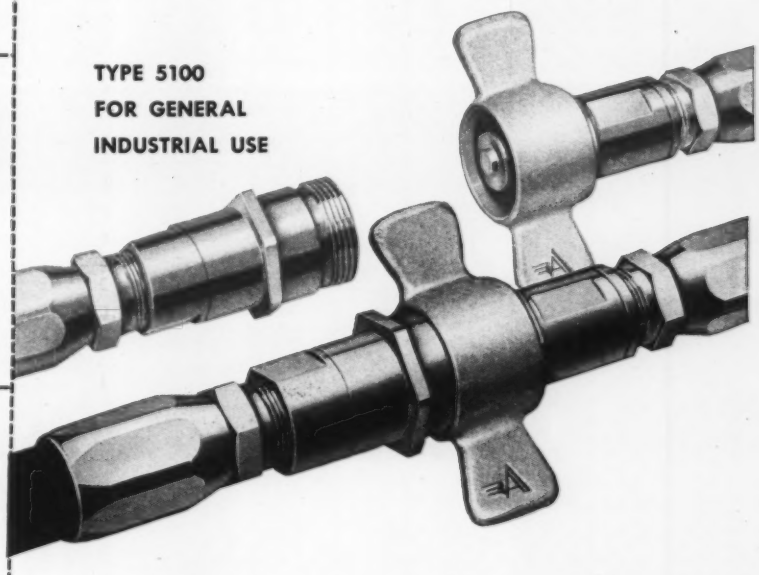
Aeroquip 5203 Self-Sealing Coupling provides quick, easy interchange of hydraulic trailing and tractor-mounted equipment. Mates with the Aeroquip Breakaway.



For Aircraft

Aeroquip 155 & 145 Self-Sealing Couplings speed inspection, servicing or replacement of engines and other aircraft fluid system components. Ideal for engine test stands.

TYPE 5100
FOR GENERAL
INDUSTRIAL USE



Aeroquip Self-Sealing Couplings permit quick connection and disconnection of fluid lines under pressure, without loss of fluid or inclusion of air into the system.

Type 5100 coupling has a wide range of industrial uses on air, water, hydraulic, fuel and lube oil lines. It is ideal for stationary and mobile equipment where fluid-carrying lines must be disconnected and reconnected frequently for servicing, moving, or interchanging of parts and accessories.

CATALOG No. 200 contains complete information on Aeroquip Self-Sealing Couplings and flexible hose lines with reusable fittings, plus valuable fluid line data. Write for your copy.

Aeroquip
REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

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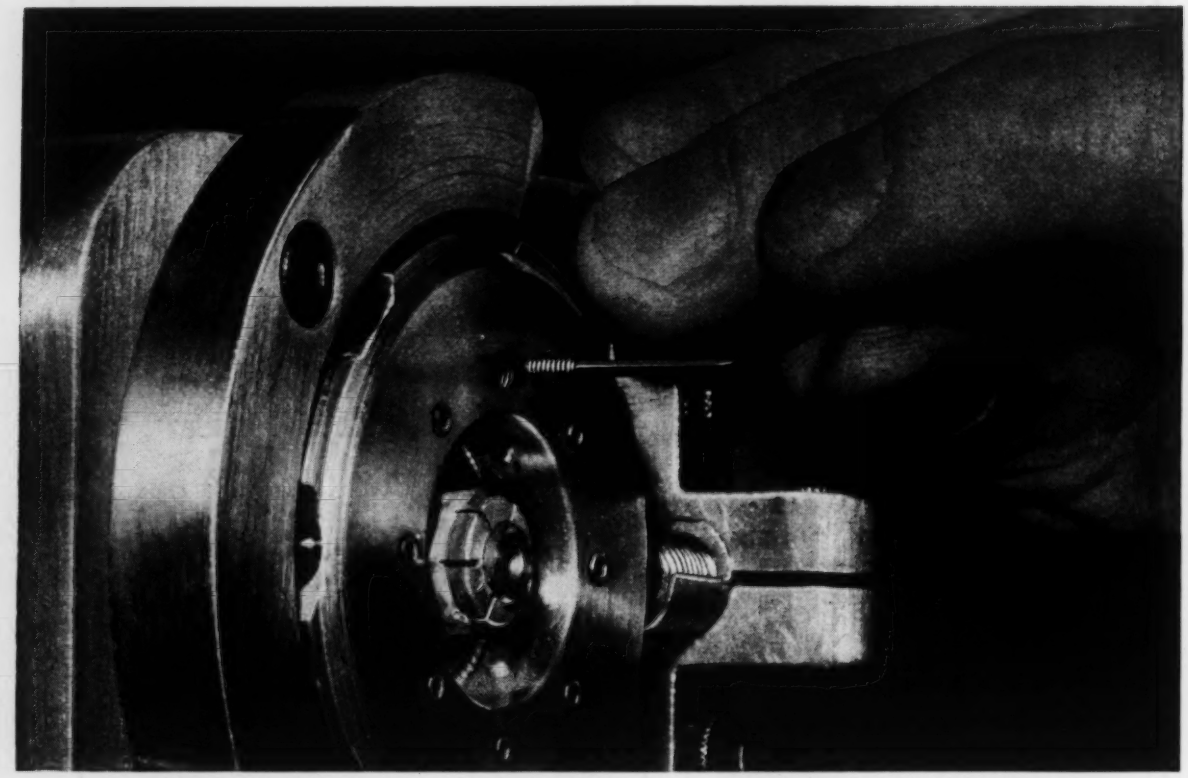
LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD • AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

—ITEM 580—



Microsize UNBRAKO socket screws simplify design problems—even in highly specialized equipment like this prototype precision loading device for use in advanced automated production operations.

Miniaturize with UNBRAKO set screws

HEAT-TREATED ALLOY STEEL*
PLAIN CUP POINT
Class 3 Fit Standard

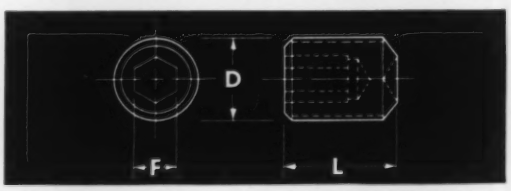
Diameter		Threads per inch NC	Threads per inch NF	L Overall Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per Box of 100 in Pounds
#0	D .060 F .028	..	80	1/16	..	.5	.01
		..	80	3/32	..	.5	.01
		..	80	1/8	..	.5	.01
		..	80	5/32	..	.5	.01
		..	80	3/16	..	.5	.01
		..	80	1/4	..	.5	.01
#1	D .073 F .035	..	72	1/16	..	1.5	.02
		..	72	3/32	..	1.5	.02
		..	72	1/8	..	1.5	.02
		..	72	5/32	..	1.5	.02
		..	72	3/16	..	1.5	.02
		..	72	1/4	..	1.5	.02
#2	D .086 F .035	56	..	1/16	1.5	..	.03
		56	..	3/32	1.5	..	.03
		56	..	1/8	1.5	..	.03
		56	..	5/32	1.5	..	.03
		56	..	3/16	1.5	..	.03
		56	..	1/4	1.5	..	.03
#3	D .099 F .050	48	..	3/32	5.0	..	.04
		48	..	1/8	5.0	..	.04
		48	..	5/32	5.0	..	.04
		48	..	3/16	5.0	..	.04
		48	..	1/4	5.0	..	.04

*Also available in stainless steel

You need not design special set screws to secure your new miniaturized equipment. Microsize UNBRAKOS were developed specifically for use in modern small devices.

UNBRAKO screws are made of carefully selected alloy steel. They are manufactured to timepiece precision. Sockets are deep and uniform for greatest wrench engagement and longest reuse. Threads are fully formed for maximum strength and exact fit. And UNBRAKOS are heat treated to the optimum condition for high tensile strength and ductility without brittleness or decarburization.

Ask your authorized industrial distributor about microsize UNBRAKO socket screws today. Or write us for Bulletin 2055 and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.



STANDARD PRESSED STEEL CO.
UNBRAKO® SOCKET SCREW DIVISION SPS
JENKINTOWN PENNSYLVANIA

—ITEM 581—

Helping a metal stretcher to form 6′ x 30′ aluminum sheets into plane parts

FARVAL—
Studies in Centralized Lubrication
No. 186

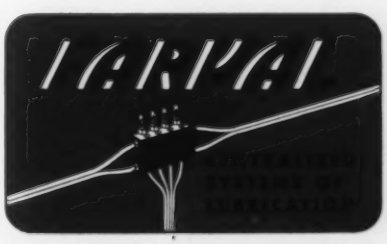
● Largest of its type on the West Coast, this 400-ton Sheridan wrap forming machine handles sheets of aluminum and other aircraft metals six feet wide and 30 feet long. It is equipped with a rapid setup panel on which the degree settings are centrally controlled, allowing the operator to work swiftly.

Farval is on the job to make sure that this swift operation continues without interruption. Through Farval's assured protection of bearings, downtime for oiling or for repairing bearings is eliminated. And, Farval contributes further to reduced costs through savings in oiling labor and lubricant.

Farval Centralized Lubrication Systems, manual or automatic, can be installed on new or old equipment. Why not let us send one of our lubrication engineers to inspect your plant equipment? He will present a written analysis of what Farval can do for you—without obligation, of course. The Farval Corp., 3287E. 80th St., Cleveland 4, O.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

KEYS TO ADEQUATE LUBRICATION—
Wherever you see the sign of Farval—the familiar central pumping station, dual lubricant lines and valve manifolds—you know a machine is being properly lubricated.



—ITEM 502—
For More Information Circle Item Number on Yellow Card—page 19